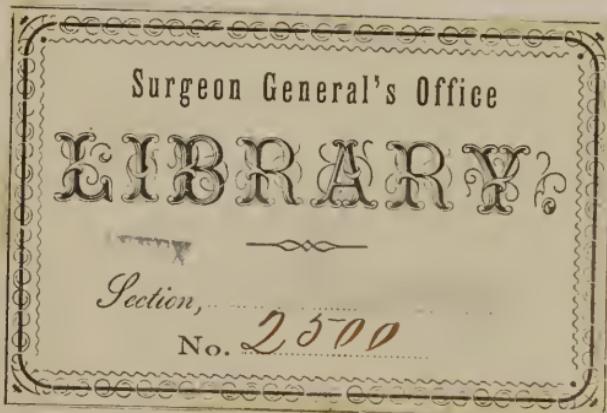
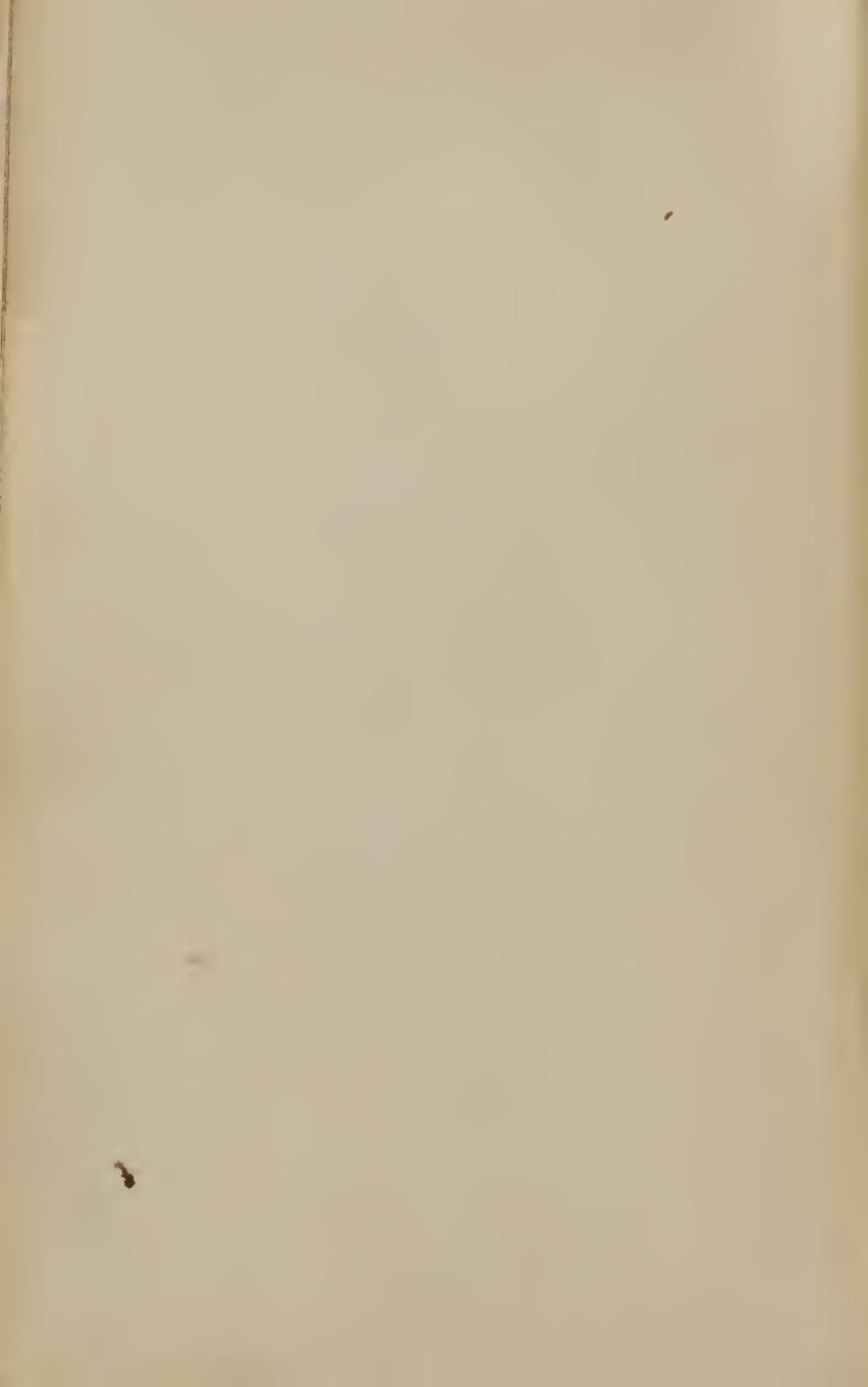


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CONTRIBUTIONS

TO

BONE AND NERVE SURGERY.

BY

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PROFESSOR OF SURGERY IN MOBILE MEDICAL COLLEGE.

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P R E F A C E.

THIS little volume is intended simply as a contribution to a department of surgery which has been strangely neglected, and in which there is a remarkable want of medical literature, viz., the *sequelæ* of gunshot and other injuries of bones.

We have works in profusion on field surgery, primary and secondary operations, organization of hospitals, camp diseases, etc., but little on the class of cases to which I ask attention.

Although the war has been over for some months, there are still thousands of soldiers scattered throughout the United States who are suffering from injuries of bones, and for years to come many of them will be seeking surgical assistance. I have been called on to treat a great many such cases and not a few of them dating their injuries back two, three, and even four years, to the first battle of Manassas.

The principles I have endeavored to inculcate are

equally applicable in civil as in military surgery, and if I can aid in directing other minds to this important field, my object will be fully attained.

The cases of injuries of *nerves* appended are probably unique, and cannot fail to interest the Physiologist and Pathologist.

J. C. NOTT, M.D.,

PROFESSOR OF SURGERY IN MOBILE MEDICAL COLLEGE.

1st November, 1865.

CONTRIBUTIONS TO BONE AND NERVE SURGERY.

THE civil war just terminated, after four years of bloody strife, has left the land filled with wounded soldiers, in all its length and breadth, dating their injuries back to the various battle-fields, from the beginning to its close; and from the nature of many of the injuries, it is evident that there will be much work for surgeons during the next year or two to come.

These chronic cases are accompanied almost invariably by fistulous openings, which have been kept discharging by the presence of dead bone, balls, fragments of shell, pieces of clothing, or other foreign bodies—the first cause being by far the most frequent.

The pathology and surgery of gunshot injuries of bones have therefore become subjects, for the first time in our country, of the highest importance, while our army surgeons, as a class, possess but meager attainments to meet the demands made upon them.

Not only has little attention been paid to gunshot wounds in the schools of America, but if we turn to the medical literature of Europe, a great deficiency will be found in connection with those chronic injuries of which I am about to speak. Guthrie, McLeod, Ballingall, Hennen, Baudens, Dupuytren and other writers on military surgery, have well covered the ground of what

might be called *primary* and *secondary* surgery; but here they stop, and we are left to grope our way in the dark in *tertiary* surgery. None of them follow up the shattered and diseased bones for months and years, and give us well-defined rules by which we are enabled to treat this large class of tedious, painful, and dangerous gunshot sequelæ.

It is true that many of our standard works in civil life, as those of Stanley, Miller, Vidal de Cassis and others, give us much information and many useful general principles of practice; but the principles and practice laid down in these works are mostly drawn from observations made on diseases of bones connected with some vice of the system, as scrofula, syphilis, rheumatism, etc., and the surgeon who turns his attention to the subject at this time will soon discover that bone pathology and bone surgery are but in their infancy. Gunshot wounds have introduced a new class of cases among us, which makes it absolutely necessary that the whole subject should be thoroughly worked over.

My object at present is not a regular monograph, but simply to blaze out a few prominent land-marks in the wilderness to assist the explorer in finding his way. As I am writing more particularly for the instruction of the younger members of the profession, I deem it proper, at the risk of being charged with prolixity, to give a résumé of those facts and general principles of bone pathology and practice bearing on the points to be elucidated, that may be found scattered through our systematic works. This will be followed by the practical application of those principles and the results of my own observations. It will therefore be convenient to divide the essay into Parts I. and II.

PART I.

THE osseous system is subject to an infinite variety of injuries and affections, which authors have found it difficult to classify in a satisfactory manner. Besides fractures and dislocations, there are many forms of disease, which, although interesting and important, do not come within the scope of our present inquiry, as they belong more to the province of civil than military surgery, and would, moreover, extend this essay far beyond its proposed limits. For example, hypertrophy, atrophy, softening, fragility, scrofula, gout, rheumatism, cancer, syphilis, hydatids, scurvy, aneurisms, etc. All these may come under the eye of the army surgeon, and not unfrequently complicate gunshot injuries, and therefore demand his attention.

My especial object is to draw attention to the rise, progress, and results or events of *simple inflammation* in the osseous tissue as witnessed by the army surgeon after gunshot injuries. In this connection I shall commence with simple *Periostitis*, *Endostitis*, and *Ostitis*, or, in other words, inflammation of the periosteum, the endosteum, and of the substance of the bone itself, all of which are so closely connected in structure and function as to partake readily of each other's diseases. They should be studied separately and in connection, and no student can hope to make a surgeon until he has mastered this department of pathology.

Periostitis.

The periosteum is a white, fibrous, membranous covering, which surrounds the bones everywhere except the articular surfaces covered by cartilage. Its external surface is united, in a more or less intimate manner, to the surrounding structures by connective tissue. Its inner surface covers the bone, whose depressions it accurately follows. It is united to the bone by delicate fibrous prolongations, and especially by numerous vessels, which penetrate its substance. The periosteum unites the bones to the neighboring parts; it assists greatly in the growth of bones, and is mainly instrumental in their reproduction in cases of fracture and other injuries.

With such structure and functions it will be readily understood that the periosteum is liable to inflammation of all kinds and grades, whether simple or specific, and that the part it plays in the practice of the military surgeon is a very important one. The bone and periosteum being so intimately connected, it is rare that one inflames without involving the other. Periostitis soon implicates the bone, producing ostitis, and in like manner ostitis soon involves the periosteum. Cold, gout, rheumatism, syphilis, etc. often produce periostitis; but for these forms we refer the reader to surgical works, as we are now treating periostitis and ostitis arising from gunshot wounds, as seen most commonly in army practice.

In *acute periostitis*, the fibrous membrane presents all the characteristics of acute inflammation; it becomes highly injected; the blood-vessels are engorged; it is

red, thickened, and softened from interstitial deposits. Its attachment to the bone is diminished; it is readily peeled off, and the connective tissue surrounding it is infiltrated with sero-albuminous matter.

Periostitis not unfrequently runs into suppuration, particularly in the bones of the lower extremity, as the tibia and femur, and in phalanges of fingers. Mortification is not an unfrequent termination of this affection, and is characterized by the dirty, ash-colored appearance of the affected membrane, its texture being broken down and emitting a very offensive gangrenous odor. The death of the periosteum coming on in this way, *generally* results in the death, to a greater or lesser extent, of the corresponding part of the bone; but the depth to which the necrosis extends differs greatly in different cases, and we have no data by which we can determine *a priori* the extent or depth of the injury to the bone; the mere *surface* of the bone may be thrown off by *insensible* exfoliation, or the death may involve any extent, from the surface to the entire thickness.

The son of a friend, Dr. F. M. Ross, received a slight flesh wound from a minié-ball on the back of the forearm, which was followed by severe hospital gangrene; the slough extending from an inch of the wrist to within an inch of the elbow-joint, and destroying all the muscles on the back and sides of the limb, leaving only the muscles lying on the anterior aspect of radius and ulna. The radius was laid bare and its periosteum destroyed for about three inches; the ulna was also laid bare some two weeks later, but only to the extent of one inch. The surface of the radius turned black, and a thin leaf of bone, not thicker than paper, was thrown off, leaving healthy granulations below. From the exposed surface

of the ulna, which was of an ivory white, no exfoliation ever took place; the granulations from the circumference of the ulcerated surface around the bone gradually closed over and coalesced; the parts healed up solidly, contrary to my expectation, without any sensible exfoliation.

I am now visiting a stout mulatto man, in consultation with Surgeon Richards, U. S. A., who had a large portion of the triceps muscle of the arm torn off by a piece of shell, exposing the humerus for an inch; some sloughing, and very copious suppuration occurred, and the periosteum was removed over the exposed part of the bone; the injury was so severe, and the condition of the wound so bad, that the arm was condemned to amputation at one time, but was spared. It is now nearly healed; healthy granulations sprung from the bone without any apparent exfoliation.

I have also under treatment a third case, in the person of one of my friends, Mr. Alexander Campbell, of Mobile. In this case acute periostitis occurred to the extent of three inches on the front of the tibia without injury or assignable cause, supposed to be from cold. The case went on to suppuration beneath the periosteum, and he experienced, for several weeks, all the intense suffering that usually attends such cases. My first visit was in consultation with another physician, and the fluctuation being distinct, at my suggestion the abscess was laid open; the pus being *beneath* the periosteum, and the surface of the bone being rough to the probe, I concluded that exfoliation would take place, and accordingly stuffed the wound with lint to facilitate both the discharge of pus and the exfoliation.

In the first two of the above three cases, the perios-

teum was destroyed by disease extending to it from the surrounding ulcerating and sloughing tissues; and there was every reason to expect that the bone would exfoliate, as this is the course usually pursued by nature where the periosteum is removed by ulceration. No *sensible*, and I think no *insensible* exfoliation took place in these two cases where the granulations sprouted up, and I believe that the internal circulation of the bone made its way to the surface and threw out healthy granulations, which soon adhered to those of the soft parts closing over them.

In the third case, the bone did ulcerate, and I passed a probe through the covering granulations and into the medullary cavity directly through its anterior wall.

It is clear from these cases that death of the periosteum may or may not involve the corresponding surface of bone in necrosis, and that we have no certain criteria by which we can predict the involvement of the bone. In the great majority of cases when the periosteum dies, the bone beneath exfoliates to a greater or lesser extent, and the same law holds with greater force in disease of the endosteum.

Periostitis, as seen in civil practice, is usually very different from that which the army surgeon has to deal with; it is there most commonly the offspring of syphilis, gout, rheumatism, scrofula, with a strong tendency to the destruction of tissues and requiring specific treatment. In army practice, on the contrary, the periostitis to which I refer is the result of gunshot injuries which rudely contuse the periosteum, or when more severe lacerate it, and at the same time fracture and splinter the bones. In these cases high inflammation ensues in the periosteum, in the bone and surrounding tissues, ac-

accompanied by suppuration, acute abscesses, etc. Sloughing to some extent both of soft parts and bone necessarily follows in the great majority of cases.

When struck by a ball, the periosteum inflames at the injured point, and in consequence of the unfavorable circumstances under which the wound is generally treated (bad air, bad diet, cold, heat, neglect, etc.), unhealthy inflammation not unfrequently is set up in the periosteum, which travels along the shaft of the bone, involving a part or its entire length. I have before me a beautiful specimen, presented to me by Dr. H. A. Schmidt, of diseased bones of the arm and forearm, successfully amputated by him just below the insertion of the pectoralis major. The patient, a soldier, received a blow from the butt of a gun on the olecranon process, which fractured it. Violent inflammation seized on the elbow-joint; next the periosteum of the humerus took on the same action, extending to the head; the bone formed one solid sequestrum in its whole length, and was surrounded by a covering of new bone, one-fourth of an inch thick, thrown out by the periosteum, and having nine openings, through which pus exuded, connected with fistulous channels opening on the surface. The ulna was diseased in like manner for half its length.

This case beautifully illustrates the intimate connection existing between periosteum and bone; the extension of disease from one to the other, and the disposition in some cases of the inflammation to extend by continuity along a bone. This kind of traumatic periostitis is usually rapid in its course at first, causing the death of a portion of the bone, and not unfrequently becoming chronic, and working on for months or years.

The following is the excellent description by Vidal de Cassis :

"In the first degree of inflammation, the periosteum is only injected, without sensible thickening; the surrounding cellular tissue partakes of this injection as well as the bone itself; the periosteum adheres lightly to the bone and is detached with facility, as may be seen in the stump of one dead after recent amputation. Later, the periosteum is redder and thickened; it is infiltrated with fluids and is more easily peeled off from the bone it covers. If the inflammation becomes *chronic*, this membrane is less red; becomes thickened; more dense, and adheres firmly to the bone.

"If the periostitis continues, it becomes further thickened and is the seat of osseous deposit. By suppuration, the periosteum is thickened and covered with fungous granulations. Pus, moreover, may be poured out, by either the external or internal surface. If there be a neighboring abscess, the membrane is at first thickened, and opposes for a time a barrier to the product of the suppuration; but by degrees it inflames, makes a part of the abscess, suppurates, and at length is destroyed, and the pus reaches the bone. It is in this way that an abscess frequently terminates by attacking a bone. Something very similar takes place in chronic ulcers, situated over superficial bones, as the tibia; but more often there is hypertrophy, ossification of the periosteum, and a kind of flattened exostosis of the tibia. In other cases, the pus commences to form *between* the periosteum and bone; the bone is then involved, and the suppuration forces its way through the periosteum, involving the superimposed tissues, and makes its way toward the surface."—*Pathologie Interne*.

The above facts make evident the danger of abscesses, even in the vicinity of bones, and the necessity of evacuating pus early to prevent its extension and complications. When pus forms beneath the periosteum, it has a tendency to accumulate and separate the periosteum

- to an indefinite extent from the bone, and thus cause necrosis; while abscesses external to the bone have a constant tendency to involve the periosteum, and through it the bone itself. After gunshot wounds particularly, we see the periosteum and bone becoming more and more involved from the burrowing of matter and destructive ulceration, all of which may generally be prevented by early and free openings, with the use of tents.

Endostitis, or Osteomyelitis.

The medullary membrane, periosteum internum, or endosteum, are names which have been given to a vascular areolar web of extreme tenuity, which envelops the marrow and lines the inner surface of the medullary cavity of the long bones, and which has been considered as the internal periosteum of those bones. It has numerous vessels which bury themselves in the thickness of the marrow, and others which nourish the innermost plates of the bones. The function of this membrane is similar to that of the external covering of the bones; it is also liable to inflammation, which often results in the death of the portion of osseous tissue nourished by it.

The cause of endostitis is usually traumatic, being the result of fractures, gunshot wounds, lodgment of foreign bodies in the bones, violent contusions, laceration of endosteum by the saw in amputations, etc. A common predisposing cause is a disordered or vitiated condition of the system, and it is often the result of abscess from injuries communicating with the medullary cavity. We occasionally have an opportunity of studying the

morbid anatomy of endostitis, in the long bones, supervening on amputations. Some days after the operation, the membrane is seen to be injected and thickened, the marrow softened, with a sero-sanguineous discharge from the medullary cavity. The inflammation progresses; the vascularity increases, and the discharge becomes purulent; the membrane after a time sloughs away; the discharge is fetid, and the external periosteum detached, and the bone dies in its entire thickness.

The *symptoms* of endostitis are obscure and unreliable, resembling closely those of inflammation of the bone or periosteum. When it occurs after amputations, where the disease is open to view, we may then connect the lesion and symptoms together; but where the disease is concealed, we are often left to conjecture. The constitutional symptoms are usually severe, accompanied by rigors, hectic, sweats, prostration, terminating often in fatal pyemia.

Ostitis.

As before remarked, inflammation of the external or internal periosteum necessarily involves more or less the bone, and inflammation of bone in like manner is readily transmitted to these membranes, which supply its nutrient vessels. Ostitis may affect only the outer plate of a bone, as in cases of slight contusion from a ball or other blow; at other times it implicates the internal surface alone; while in a third class the entire thickness of the bone is involved.

The *causes* are the same as those enumerated for the production of periostitis. Ostitis may result in ulceration simple or carious; in necrosis; or the action may

be of a lower grade, leading merely to a *change of structure*.*

I shall never forget a blunder I made thirty-five years ago, the first year of my practice, at a time when little was known or taught of bone pathology in this country.

A negro man was brought to me from the country, with a painful enlargement of the tibia, of several years' standing, and without any assignable cause. On examination I found the bone enlarged to double size; it was warmer than natural; was often the seat, particularly at night, of severe pain, and incapacitated him for any prolonged labor, although he was a good portion of his time moving about. He had received no injury that he recollects; had no scrofulous or syphilitic taint; there had been no ulceration, abscess, or purulent discharge of any kind, and no evidence of any disease but simple inflammatory hypertrophy.

In the fullness of my pathological ignorance, expecting to find necrosed bone, I cut down upon the enlarged shaft of the tibia at its most prominent point, about the middle, and chiseled off a portion of what I supposed to be a cortical formation, within which I expected to find

* The periosteum, we have seen, is freely supplied with blood-vessels from the surrounding tissues. The endosteum is also freely supplied in the long bones mainly through the nutritious arteries which perforate the shaft, get to the medullary cavity, and ramify freely up and down through its whole extent. The substance of the bone itself, receiving vessels from both these sources, is exceedingly vascular, as may be seen by injecting it through either of the above sets of vessels. The extremities of the bones particularly which are spongy in structure are very liberally supplied with blood. The anastomoses of the vessels of the periosteum, the endosteum, and bone are very free, and it is therefore easy to comprehend how inflammation passes readily from one to the other.

a sequestrum. But my surprise and mortification may be imagined when I failed to find dead bone or internal suppuration. The bone being rarified, its blood-vessels greatly enlarged and multiplied in number, the blood oozed from every pore of the chisel-cut, as it would from any other inflamed tissue, and I for the first time discovered that I had to deal with *structural change*, from chronic inflammation, falling short of caries or necrosis.

I learned an important lesson from this case when I came to study it out, and I relate it for the benefit of the young surgeon, as I have witnessed many similar blunders in others since. The lesson was this: wherever caries or necrosis exist, there *must be suppuration*; and this suppuration must be revealed, after a certain time, by the presence of one or more sinuses, leading to the dead or dying structure. I learned, moreover, never to cut down upon a bone before there is evidence of the existence of pus.

Change of Structure.—This, we have already hinted, is one of the results of inflammation, and may attend the latter either in its simple or specific forms. In this grade of morbid action, the bone is at first softened, apparently by absorption of a portion of its earthy matter. The texture at the same time becomes more open and spongy; its surface presenting a porous appearance, as if the enlarged vessels had pushed aside the solid structure. The bone itself becomes expanded, enlarged, vascular and less dense. As the action becomes chronic, lymph is deposited, becomes organized, transformed, and there is condensation and induration of structure. The bone becomes larger, heavier and more dense, resembling ivory. The bone is now less vascular, is impaired in vital power, and therefore less likely to resist a reacces-

sion of inflammatory process. Liability to suppuration, ulceration, and necrosis is increased. If the morbid action ceases, and care be observed, in the course of time nature does much toward restoring the bone to its normal condition, although it never regains its original dimensions.

The *symptoms* are very like those of periostitis; deep-seated pain, with nocturnal exacerbations; puffiness; tenderness; redness; fever, etc. The treatment, like that of periostitis, is antiphlogistic, with iodide of potassium and mercury.

Suppuration of Bone.—When acute periostitis occurs, the subjacent bone is soon involved in the inflammatory action; effusion takes place between; if the vascular action runs high, abscess is there inevitable, and such cases are common from gunshot injuries. Pain is excruciating; distinct rigors usually accompany the formation of matter; swelling follows, and ultimately fluctuation, with redness and all the signs of superficial abscess.

In those cases of periostitis accompanied by severe pain and effusion of serum and lymph, with tendency to suppuration, it is proper to make a small opening at the lower part of the swelling, introduce a probe-pointed knife flatwise, pass it along between the skin and periosteum to the upper border of the swelling, then turning the cutting edge toward the periosteum, and while withdrawing the knife, divide the periosteum *subcutaneously* down to the bone through the whole extent of the swelling. By this procedure, tension of the periosteum is taken away, pain is greatly relieved, and an exit given for pent-up fluids, which are causing pain and tearing up the periosteum from the bone. If this had

been done sufficiently early in the case of Mr. Campbell, above related, most of the suffering and loss of time would have been saved. A subcutaneous cut of this kind can never do harm, and is often productive of great good. If pus has already formed, it is only a stronger reason for making an opening; but where we are *sure* that suppuration has taken place, it is better to make a free incision with a bistoury through the skin and other tissues down to the bone, stuff it with lint, give the pus free exit, and allow the wound to granulate from the bottom. The bone may exfoliate, but if it should, this is still the best practice.

When in such cases the matter is easily discharged by a free opening, the ulceration of the bone ceases; the surface becomes healthy; granulations spring up, and cicatrization follows. If the incision be omitted, the matter burrows; the disease extends in every direction; the patient suffers intensely, and the constitution deeply sympathizes. The periosteum is gradually separated from the bone by lateral extension of the abscess; the bone dies from the want of its accustomed supply of blood through its investing membrane, and the pernicious effects of putrid pus in contact with it. The periosteum becomes more or less destroyed by ulceration, and a probe introduced through the external opening will readily detect the denuded and roughened bone.

Instead of forming on the surface as above described, small circumscribed abscesses occasionally form in the substance of bone, and particularly in the cancellated structure of the extremities of long bones, and more particularly in the tibia. The intense local pain, tenderness on firm pressure, constitutional disturbance, sleepless nights, etc. declare the seat and nature of the

affection, and a trephine should be applied, which by the discharge of a small quantity of pus affords immense relief.

Instead of a circumscribed abscess, the inflammation being of an asthenic or unhealthy character, suppuration pervades the internal, particularly the cancellated structure, resulting in the destruction of bone, and often death, through hectic fever and pyemia. On the other hand, cases occur in which the most violent acute inflammation seizes upon the bone, pervading the whole thickness and leading rapidly to necrosis. The pus not only burrows beneath the periosteum, but diffuses itself through every pore of the portion of bone attacked, and implicating the neighboring soft parts, works its way to the external surface. If a bone be sawn through in this condition, pus is seen everywhere oozing out from the cut surface.

Ulceration of Bone.—This may be simple and manageable like a simple ulcer in the soft parts, or peculiar and difficult to cure as in *caries*.

Simple ulcer of bone is the product of simple inflammation, however induced, and although it occurs without contact of air, it is likely to be aggravated by its presence. I am satisfied that an exposed, ulcerating bone, when well protected from the air constantly by wet lint or cotton, generally extends less and granulates sooner, than when not thus protected. As soft tissues may inflame, suppurate, and ulcerate, so may bone, the inflammatory process originating in and being nearly limited to the ulcerated part. Not unfrequently, however, the site of the ulcer is not that which was primarily, but that which is secondarily involved. An abscess, occurring either by osteitis or by inflammation

of neighboring soft textures, compresses a portion of bone not originally inflamed, and thus induces its molecular destruction. Such pressure may come from without or within; the abscess may form in the soft tissues and cause ulceration on the surface of the bone, or suppurative ostitis having occurred in the cancellated structure, and the pus making its way *outward* by ulcerative action, in obedience to a general law, an opening in the bone is formed. A minié-ball, for example, may pass through the fleshy part of the thigh or leg, without touching the bone, and an abscess will form, extending down to the periosteum, then to the bone itself, producing in some cases simple superficial ulceration of the surface of the femur or tibia. Or if the action be more intense, and the constitution deranged, necrosis may ensue in a large portion of the shaft of the bone, implicating the cancellated structure, destructive ulceration is apt to involve not only the head of the bone, but the neighboring articulation, requiring amputation.

So long as pressure from the swelling or accumulation of pus continues, ulceration advances with more or less rapidity, but ceases on its removal, and the process of repair commences; healthy granulations sprout up from the ulcerated surface of the bone, as from the surface of an ulcer in soft parts, and are slowly converted into bone; thus supplying to a considerable extent the part destroyed by ulceration. All this is the result of *simple* inflammation, identical with that of soft parts, and requiring the same general principles of treatment.

Caries.

By this term we designate a morbid action of very different character. It may follow simple inflammation, but more frequently it is primary. Although not malignant, it is something more than what is called weak ulcer of bone, and is a term which has been far too loosely and indiscriminately employed.

Caries is a breaking down of the structure of bone, a peculiar action, which, left to itself, is almost incapable of cure. In dense bones it is preceded by interstitial absorption, which gradually softens the structure; but it is in the cancellated structure, as the extremities of long bones, and the carpus and tarsus, that this morbid action is most commonly seen.

The margins of the cavity in caries have not the abrupt and firm character of simple ulcer, but are soft, spongy, and worm eaten in appearance, without defined limits. It has no adequate power of reparation; it may be open and uncovered, giving a crumbling sensation to the probe when introduced into it, like a loaf of bread or piece of decayed wood; or it may be covered by tall, flabby granulations, incapable of transformation into bone. The ulcerative process is usually chronic, and the destruction of bone slow, though sometimes it is acute and rapid. The whole of a small bone, even the whole of a chain of small bones, or all the articulating extremity of a long bone, may be attacked, or a thin external portion alone may suffer. A thin, fetid, purulent discharge, often bloody, always acrid, usually more or less mixed with ulcerative débris, and often containing small detached sequestra, exudes in considerable

quantity. The surrounding soft parts are swollen, infiltrated, and broken up by suppuration. One or more openings take place in the integuments, presenting the characters of a weak, scrofulous, or irritable ulcer. A probe passed in through these apertures reaches and penetrates the softened bone. Caries may be simple, scrofulous (tubercular), or syphilitic. The first is the variety I wish to call attention particularly to, as most frequently seen by the army surgeon in the spongy bones of carpus, tarsus, and extremities of long bones, from gunshot wounds. Persons of strumous or syphilitic constitutions are, of course, more liable to caries; but yet it is often seen as a consequence of wounds in others, particularly in hospital practice, where the air, diet, etc. are bad. Under all circumstances, the constitution is liable to suffer severely.

The *treatment* requires much tact and care when developed, and the surgeon should use all his skill to *prevent* it. When inflammation occurs in the soft parts covering bone, or in the periosteum or bone itself, active antiphlogistic treatment should be adopted, together with perfect quiet of the part. When suppuration occurs, the matter should be evacuated early, and the treatment for acute abscess and ulceration be rigidly pursued. The condition of the system should be carefully attended to. If action runs too high, deplete; if too low, give tonics, generous diet, etc. If it be scrofulous or syphilitic, appropriate specific remedies must be employed. In army practice the supporting treatment is almost invariably called for.

After caries has fairly set in, there is no alternative left but removal of the diseased bone by surgical interference. All the disorganized parts should be removed,

and the surgeon must not stop until he reaches perfectly sound bone, from which granulations may sprout. When this is done, the part may be treated as a simple ulcer.

A very important rule in these operations is too often overlooked, and instead of good much harm is done by the ill-timed interference, viz.:

"No operation of any kind should be performed on the bone, unless the adjacent and superimposed soft parts are in a quiet state. They may be undergoing the acute inflammatory process; they may be the seat of acute suppuration, of acute ulceration, or of both; and the removal of a portion of bone imbedded in such parts is almost certain not only to prove futile as a means of cure, but actually to aggravate and extend the disease. The carious portion of bone may be taken away, but ulceration, instead of reparation, is certain to ensue, and, by rapid degeneration, the carious condition is renewed. Or a more intense and general ostitis is kindled, and the partial caries is merged in general necrosis."

Too much weight cannot be given to the above general rule laid down by Professor Miller, of Edinburgh, in his *Principles of Surgery*. I have again and again seen it violated to the great injury of the patients, during the recent war, both in caries and necrosis.

After proper treatment has been pursued, sufficient time has been allowed for inflammation and suppuration to subside, and the acute sensibility of the soft parts has disappeared, a free incision should be made, so as effectually to expose the diseased bone, and by the saw, trephine, bone pliers, or gouge, it should be thoroughly removed. The articulating surfaces of long bones are managed best by the saw; in the flat bones, as the cranium or scapula, the trephine is often most convenient; while in the shaft of long bones, in the bones of

the tarsus, etc., the gouge is most efficient. In some cases where the disease cannot be well circumscribed by cutting instruments, escharotics, as chloride of zinc, red precipitate, or caustic potash, may be substituted.

For information respecting caries in those parts of the skeleton not accessible to the knife, as chronic affections of some of the large joints, vertebræ, pelvis, we refer the reader to surgical works. The army surgeon is rarely called on to treat them.

Where the carpus or tarsus is deeply involved, complete excision is the only reliable remedy; and for the application of this remedy to the wrist, the reader is referred to an admirable article in the July number (1865) of the *London Lancet*, by Mr. Joseph Lister. To make the operation effective, he recommends that not only the whole carpus, but the articulating ends of the radius, ulna, and the bases of all five metacarpal bones be removed.

Necrosis, or Death of Bone.

The vitality of a bone may be destroyed in a few seconds by fire, or strong acids, etc.; usually, however, it is the indirect result of injury, the bone perishing by violent inflammation.* When unaccompanied by any

* The causes of necrosis are all those already enumerated for osteitis and periostitis. The following instance from Mr. Stanley's work is curious and interesting.

In enumerating the causes of necrosis, Mr. Stanley makes the following interesting statement: "During the progress of fever, necrosis of the shaft of a long bone has occurred without any evidence of previous inflammation, either in the periosteum or medullary tissue. And here it might be suggested, that the inflammation and death of the bone are analogous phenomena to the local con-

other form of disease, it is said to be *simple*. *Compound*, on the other hand, if combined with caries, or attendant on fractures, as often seen in gunshot injuries. When consequent on wounds, or other external injury, it is called *traumatic*; and *idiopathic* when arising without assignable cause. Often, in the young, a bone is acutely inflamed without any apparent reason, and rapidly becomes the seat of suppuration and dies to a greater or lesser extent.

Necrosis may also be either *acute* or *chronic*, according as the inflammation which leads to it assumes one or the other type. In one sense, necrosis is always chronic, for the separation of the dead from living bone, and the formation of a substitute always requires time, while the inflammation may be of low grade.

Necrosis differs greatly in its extent—a mere leaf or scale may be thrown off from the surface, and this is called *exfoliation*. A larger portion of the compact structure may die, or this may retain its vitality while the cancellated interior perishes. The dead portions or *sequestra* are called *external* or *internal* accordingly, and like terms are applied to the necrosis. Again, the whole thickness of the bone dies in one continuous mass, and the disease is then said to be

gestions and inflammations occurring, under similar circumstances, in other organs. In a young female, necrosis of the entire shaft of the tibia occurred during an attack of fever, from which she died in about a month from its commencement. I found the tibia throughout its osseous substance of a deep-red color, while the medullary tissue was unaltered. But that the bone had perished was evident, by the entire separation of the periosteum from it, and by the lines of separation commencing between the shaft and articular ends. Here, therefore, it appeared that inflammation in the tissue of the bone had preceded its necrosis."

general. This general necrosis differs much in extent, involving a part or even the whole of the femur or other long bone.

It is seldom, however, that the entire bone suffers; usually the articulating extremities remain, the line of separation occurring about the position of the epiphyses. This fact is well known to surgeons, and it is fortunate that it is so; the process of reproduction is thereby facilitated and the joints are saved from all the horrors of disorganizing articular inflammation.

The cancellous portions of long bones, and the smaller bones of spongy structure, as those of the carpus and tarsus, are most liable to caries, while the compact portions are the common seats of necrosis, and this accounts for the fact that the latter kind of action stops at the articulating extremities of the long bones. The extremities, however, are not exempt either from involvement in general necrosis of the shaft, nor from the disease occurring in a more limited form within themselves. It may be the result of some vice of constitution or of injury. Wounds or injuries of the cancellated structure of long bones near a joint are always dangerous, as the joint soon or late is generally involved.

Necrosis, like other diseases, has its *stages*, and to comprehend fully the process, they must be watched from beginning to end. In the *first stage*, a portion of bone inflames. This may be the result of external injury, as wound, contusion, or fracture; or it may be apparently of spontaneous origin; it may terminate in local death, either in consequence of its own intensity, or on account of this being associated with diminished power in the part affected. The associated cause is more frequent than the single, in cases of traumatic

origin, the injury not only kindling ostitis, but, at the same time, diminishing the vital power by which it is to be opposed. This remark applies with peculiar force to gunshot injuries of bone.

It often happens in wounds, that a portion of the periosteum is removed from a bone, or it is so contused as to destroy its vitality. Such injuries impair the power of the bone, and, if ostitis supervene, necrosis is *apt* to follow, but not *necessarily*. The periosteum is sometimes rudely torn off and still the bone granulates, a new periosteum is formed, and the injured bone lives; it may even survive acute ostitis. I have already given cases in which the periosteum was removed by ulceration and gangrene from the external surface, and yet the bone has survived without exfoliation. Such cases, however, are exceptions to the general rule, *that when the periosteum is removed by disease, the corresponding surface of bone dies.*

But if the periosteum and endosteum both be stripped off, or removed by disease, the death of the bone to the extent implicated is certain to follow, from want of a sufficient supply of blood.

"A marked sympathy of function has been observed between the periosteum and endosteum. When the former has been destroyed, the corresponding portion of the latter becomes peculiarly active, often causing an obliteration of the medullary canal, at that point, by deposit of bone. After injury to the endosteum, similar sympathy is evinced by the periosteum. In fact, destruction of either membrane involves an increased duty and activity of production in that remaining.

"When exposed bone retains its vitality, it is of a brown hue; sounds dull on being struck; emits blood when rudely handled, and is covered by a self-secreted fluid. On the contrary, if it be dead or dying, its color is white; it is

resonant when struck ; it is dry, unless when moistened by purulent secretion from the surrounding parts, and does not bleed when touched, however rudely. Such signs are useful as not only auxiliary to diagnosis, but bearing strongly on the mode of dressing. It must, however, be also well understood, that a bone stripped of its periosteum may, at first, show all the usual indications of retained vitality, and yet whiten and die. And, also, that an exposed portion of bone may become white, sonorous, and apparently non-vascular shortly after the infliction of the injury, and yet recover with the thinnest possible exfoliation. In the latter class of cases, the process of renewed and increased vascularization, in a part previously exsanguine, may be seen beautifully exemplified."—*Prof. Miller, Principles of Surgery.*

In the *second* stage the bone dies, and the process which leads to it may be completed in a few hours; but in others, it requires days. While the inflammation was in progress, the periosteum was adherent, but now it is detached and pus infiltrated between it and the bone. If the death of the bone be rapid, it has had no time to change its structure under the inflammatory action resident in itself, and it consequently, as a sequestrum, retains the character of normal bone. Its external surface is compact—looks like healthy bone, which has been macerated and stripped of periosteum. But if osteitis have existed in the part for some time previous to its death, then its appearance will vary when dead, according to the duration and intensity of that action—rough, porous, swollen, ulcerated, dense, etc. The first condition is most frequent.

The *third* stage in the process is *the separation of the dead from the living bone.* The second stage, or death of the bone, is often rapidly completed, and is never long protracted; but this third stage is invariably slow. The detachment is effected by the same vital

action, that sloughs in soft parts are separated, but the time consumed differs greatly in the two. A slough may separate in a few days, while weeks or months may elapse, and the detachment of a sequestrum be still incomplete.

The extent of the necrosed portion is indicated by its denuded, white, sonorous, insensible, and non-vascular characters, and these it retains through the whole process, resembling a macerated bone. No change occurs in this except that of color from exposure to air or unhealthy pus, it becoming, sometimes, black. But great changes are progressing in the parts *contiguous* to the dead bone. There is great activity—the color of the living bone is red, or dark-brown, from increased vascularity; it is painful to the touch and bleeds readily; lymph is exuding and the part becomes softened from loss of earthy matter; it is also swollen. While the dead bone remains a foreign body, the parts all around are soft, swollen, and increased in vascularity, carrying on the inflammatory process. This soon terminates in suppuration and ulceration, and at the *line of demarkation*, the absorbents commence their work, and, step by step, the sulcus between the dead and living portions is deepened, until the former is completely detached, reducing it to the condition of a sequestrum. This process requires an indefinite, and often long time.

Rokitansky, in his Pathological Anatomy, denies the action of the absorbents in the separation of dead from living bone, but this is rather a dispute about words. The following is his view of the matter:

"All around the necrosed portion, that is to say, its margins and at the part where its surface is opposed to that

of the healthy bone, the latter undergoes a gradual expansion or rarification of its tissue by the enlargement of its Haversian canals, assumes a rosy color and becomes succulent. It acquires gradually an areolar structure, and is thus more rarified : at length it disappears altogether, and a red, soft, spongy substance, a layer of granulations, occupies its place. This change is produced by an inflammatory process, which gives rise to suppuration and granulation : the bony tissue, beginning with the Haversian canals, is dissolved by the matter secreted within them, while the granulations which shoot forth at the same time, fill up the enlarged canals. The immediate result of this process is the formation of a furrow of demarkation which encircles the margin of the dead bone and is filled with granulations ; and so far as the process is completed on that surface, also of the living bone which faces the dead, so far is the sequestrum separated. In this process, that is, in the solution of the layer of healthy bone adjoining the dead by means of the purulent matter, and in the attendant formation of granulations, I find enough to account for the demarkation and separation of the sequestrum ; and the absorption which has been assumed to go on at the borders of a portion of necrosed bone, I hold to be incompatible with inflammatory process, while the analogy of the process by which mortified soft parts are cast off renders such a view admissible."

I am not prepared to receive, without a doubt, the above views of Rokitansky. I think there are good reasons to believe that not only living and dying bone, but dead bone may be acted on by absorbents. We know that pressure upon a living bone, as by aneurisms, tumors, etc., will cause its absorption. It is equally true that granulations do possess great absorbing power, as is proven by the absorption of morphine, arsenic, strychnine, and other soluble salts, when sprinkled on them ; and one of the worst cases of salivation I ever saw, was caused by inserting calomel (an insoluble powder) into an abscess. On the other hand, I know

of no facts to prove that *pus* has any power of dissolving dead or living bone.

It is true that a loose piece of bone will float about in a pus cavity for months or years without losing weight, but this does not prove that a sequestrum, when closely applied to granulations, may not be acted on by their absorbents, and I do not see how else we can explain the worm-eaten appearance of dead bone and its intimate relations with the underlying granulations.

Mr. Savery's experiments (see vol. xxix. Med.-Chir. Transactions, 1864, London) prove that pegs made out of the compact substance of the shaft of a human femur, when driven *tightly* into the bone of an animal and left there for some weeks, are found to have *diminished in their weight*. Mr. S. attributes this absorption to the effect of *pressure*; and the same law may apply to the sequestrum pressing on granulations. It is probable that the close *apposition* has as much to do with the absorption as pressure, for we can easily conceive how granulations might act, through their absorbents, on a bone or other substance in close contact, where they could not if the same substance was floating loose in the superimposed pus.

Mr. Stanley, in his "*Treatise on the Diseases of Bones*," gives some strong corroborative facts, of which I can only quote a paragraph or two.

"In a case where a portion of the front of the tibia perished and had become of a black color, granulations from the surrounding soft parts were observed to extend gradually over the dead bone. While this was in progress, I raised upon the edge of a spatula, the free border of these granulations, and exposed little hollows in the surface of the dead bone, to which the granulations were exactly fitted. In these several instances, the dead bone certainly disappeared

but not by any sensible exfoliation; the question will be respecting the mode of its disappearance.

"Miescher has attempted to explain the facts by the agency of what he calls *insensible exfoliation*, but to my mind both facts and reason are in favor of absorption of bone."

I have seen many cases similar to that related above by Mr. Stanley, and have already related two. The argument of *insensible exfoliation* in these cases has been drawn in part from the fact that much earthy matter is found in the pus; but it should be borne in mind that it is a function of bone granulations to supply bone material.

When a slough separates from soft parts, the process of repair has already commenced and follows closely upon the separation—granulations sprout at once from the sound surface, as fast as the absorbents divide the parts, and the work of repair steadily progresses. Precisely the same course is followed by nature in the necrosis or sloughing of bone. As soon as the sulcus is formed, granulations begin to spread, and here, in accordance with the law of diseased tissue, they are *osseous granules*, soon to be transformed into bone.

The process of separation is always slow, and it is well that this is so, as that by which bone is *formed* is always so. The work of destruction and repair, by a wise provision of nature, advance together without interference. The old bone is not thrown off until the new formation has sufficient strength to supply its place.

There is necessarily during the process of separation a copious formation of pus, which either discharges through natural openings, already existing, or it burrows around, often doing much harm to parts not before involved. The surgeon should watch closely, and make

sufficient openings in dependent parts and keep them open by the insertion of lint. The discharge is usually thick, yellow, and charged more or less with ulcerated debris, and of peculiar and very offensive odor, readily recognized as characteristic of necrosed bone; it contains earthy matter.

In the *fourth stage*, the *separation of the dead bone is completed*, the ulcerative process having encompassed it on all sides. It is now loose, except where hemmed in by the formation of new osseous matter, as is often the case. The sequestrum is now a foreign body, having lost all vitality, and as such keeps up inflammation and suppuration, and cannot be too soon got rid of.

Sometimes the death and separation is not in one mass; but a gradual disintegration and destruction of the bone occurs, in particles so small as to escape observation—a process which has been very properly called *insensible exfoliation* by Miescher, who has, however, I think, given it too wide an application.

In the *fifth stage*, the dead bone is *extruded*, like any other foreign body, by the process of suppuration and granulation; it is gradually floated to the surface and exposed. Nature is sometimes powerful enough to throw it out completely, but usually the assistance of the surgeon is required, and can always hasten the process and save much time. The granulations gradually advancing, will sometimes push the dead bone entirely through the opening in the soft parts, but on the other hand, they not unfrequently surround and embrace it so as to retain it in its position. The granulations not only incase it, but they will shoot into its irregularities and openings, so as to nail it down firmly. These irregularities and perforations of the dead bone are

generally believed to be the result of the ulcerative process before the bone had lost its vitality, and although this is doubtless true to a great extent, we have given reasons for the contrary opinion, that granulations in close contact with dead bone do, through their absorbents, act upon and eat into it.

In the *sixth stage reparation* is completed after being commenced in the old bone, at the time of separation on the living margin. It advances in two parts, deep seated and superficial: the former, following close in the track of ulceration, consists of bony production from the living bone, beneath the loosening sequestrum; the other is carried on by the periosteum, and invests the dead bone on the exterior, gradually enveloping it like the bark of a tree, and hence called *cortical* part of the *substitute*.

It has been proven that periosteum is the principal agent in the reparation of bone. The ulceration will form openings here and there in the periosteum for the discharge of pus, and, at these points, there is a deficiency of the cortical or new bone, and a probe passed in at these points will strike the dead sequestrum beneath. These openings usually remain until the sequestrum is removed. The openings through the cortical formation are called *cloacæ*, and afford proper drains for the accumulating matter. There is sometimes one, and at others, several; as many as eight or ten of these openings terminating on the external surface, in a little elevated orifice called the *papilla*. The probe readily finds its way through these openings down to the sequestrum, and the condition of the bone from time to time may be examined, and when it has become loose, one of the openings should be enlarged and the dead bone removed.

When it has been removed, the cavity is gradually filled by osseous matter, and the substitute or new bone is completed. There being no longer any dead body to keep up suppuration, it ceases, the cavity fills up and contracts, and all becomes firmly consolidated.

Surrounding the diseased parts, before the dead bone is removed, there is much swelling and hardness from the copious deposition of lymph, but absorption now takes place, and the thickened soft parts are in due time brought down to their normal dimensions. Enlarged bone rarely if ever regains its former size, though all its functions are restored.

What we have heretofore said has been mainly in reference to disease of the exterior periosteal surface of bone. When the necrosis is *internal*, a part only of the cancellous texture having died, reparation follows rapidly on extrusion of the sequestrum. The sequestrum makes its escape through an aperture, formed by ulceration, in the laminated portion, which opening, like that described in the *cortical* formation, is called *cloaca*. When the sequestrum by art or nature has been removed, reproduction is accomplished entirely by the surrounding living bone, which constitutes the parietes of the cavity in which the sequestrum is incarcerated. In the diseased action which precedes this internal necrosis of the walls of the medullary cavity, the internal periosteum or endosteum is destroyed by ulceration, and the bone itself is therefore the only source of reproduction.

Where the inflammatory action has been limited, the internal sequestrum is small, and also the suppuration. The ulceration by which the bone is perforated for the discharge of the sequestrum and pus may be very

tedious. The presence, however, of the foreign body keeps up a low degree of ostitis; the bone often becomes much enlarged, condensed in structure, and often roughly nodulated on the exterior. The whole shaft of the bone may be involved, with only a small opening or two through which the pus escapes.

Instead of the disease being confined to the external or internal surface, it may attack the whole thickness of the bone, and the process of separation advances in the usual way, as also the commencement of reparation, viz., osseous production from the living margin of the sulcus. The bone itself does a part of the work, but most of it is accomplished by the periosteum, which forms a complete casing of the dead portion; the sequestrum, by means of ulceration, suppuration, and granulations from the living surface, may be gradually extruded from its nidus, by the efforts of nature alone. The new cortical formation then contracts, and with the aid of what is contributed by the old bone, a solid, efficient substitute is finally formed.

"Complete reproduction, however, is not to be expected in all cases. If a small portion only of the entire thickness perish, say half an inch or an inch, doubtless it will be ultimately, though slowly, reproduced; the parts are equal to the task required of them. The bone more especially is quite able to undertake its part of the duty; the osseous formation from either end uniting to form a dense and compact reunion of the central portions of the shaft. In all cases, the periosteum, when left entire, is capable of executing its share, namely, formation of the cortical portion. But this is not enough; the cortical portion, if left to itself, after extrusion of the sequestrum, unsupported by internal production from the bone, shrivels and bends—is altogether insufficient as a column of support, and ultimately becomes, in a great measure, removed by absorption. Now, reproduction from the mutilated osseous surface can only extend a cer-

tain length. In the higher classes of animals, reproduction of tissue is not indefinite, but has its limits. The two portions of bone will shoot out new matter readily, so as to effect union by restoration to the extent of an inch or two; but, in seeking to traverse a greater space, the reparative process is apt to flag and fail; the osseous granules do not coalesce, but taper finely off, ending in a point coherent with the condensed, soft tissues around. Therefore, practically, it must be remembered, that when a sequestrum has come away, including almost the entire shaft of a long bone, reproduction can scarcely be expected to prove complete; and probably the limb will ever after be more or less inefficient as an organ of support and motion.

"It is astonishing, however, how successful the restorative effort sometimes proves, even in circumstances of little hope; in not a few instances long bones have been almost wholly reproduced; and therefore in necrosis of the entire thickness of the shaft, even of great extent, a chance of cure, in the ordinary way, ought to be invariably afforded. The short bones, however, if wholly necrosed, are never reproduced, and reproduction is also rare in the flat bones, especially the cranium."—*Miller's Principles of Surgery*.

Professor Miller's reasoning and conclusions are doubtless drawn principally from the class of cases of necrosis seen in civil hospital practice, which are usually very different from gunshot injuries in soldiers. In the latter class of patients, the power of reproduction is much greater than the professor admits. After resections it is common to see large portions of bone reproduced. After resections of the humerus, I have certainly seen as much as three inches of bone reproduced, and the length of the arm fully maintained. One of these cases was Gen. Daniel Adams, of Louisiana, who had about three inches of the humerus taken out by a surgeon (Dr. Moses, I believe), after one of the battles in Tennessee. Exfoliation of the ends of the bones followed in consequence of the high inflammation and

profuse suppuration, and about ten months after the injury, I removed, by incision, four small fragments, completely incased, except the cloaca, in a thick cortical formation, bridged across, between the ends of the bones; the cavity soon closed, the bone became firm, and the use of the arm is now perfect.*

For the reproduction of bone, under any circumstances, it is essential that true inflammatory action should subside; otherwise, healthy fibrin will not be deposited, but destructive ulceration and suppuration result. As long as there are much inflammation and suppuration, there is danger of extension of the disease, and the involvement of new portions of bone.

Symptoms.—Necrosis being the result of inflammation, the symptoms are in the early stage those of acute osteitis, and, when suppuration occurs, they are aggravated by tension and pressure. As soon as the pus finds vent naturally or artificially, there is marked relief. An opening should be made as soon as fluctuation is discovered, not only for the relief of pain, but to arrest extension of the disease. The soft parts around are infiltrated with serum and plastic matter, and are the seat of redness, swelling, heat, and pain.

One or more openings are established through which the pus escapes, and a probe introduced will pass through the cloaca and come in contact with the dead bone; this channel becomes fistulous, and will remain open for an indefinite time. If the opening be large enough, the finger is the best probe. The sequestrum

* The remarkable case of M. Maisonneuve is one strongly in point. He removed twelve inches of the tibia, leaving only the periosteum, and the bone was reproduced, and made a good and efficient limb.

may be within the medullary cavity of a long bone, or on the external surface covered by bony product of the periosteum.

Instead of the constitutional symptoms which accompany acute osteitis in the first stage, as the suppuration advances the powers give way and hectic follows with all its train.

So long, however, as the sequestrum remains, nature makes increasing efforts to throw it off, and local inflammation is kept up. While the absorbents are at work cutting loose the condemned portion, the periosteum and living bone are doing their work of repair, are reconstructing the substitute. The soft parts at the same time are much thickened and increased in vascularity; so that when incised, they cut more like gristle than ordinary soft textures. Hemorrhage, under these circumstances, is always profuse for two reasons: *first*, there is an increased *number* of blood-vessels; and, *second*, from the inability of the vessels to contract, in consequence of being held open by the dense, unyielding tissues in which they are imbedded.

After the inflammatory action has subsided to a great degree, and the disease seems to be approaching its termination, the morbid action is again lighted up from trivial provocation, and often without apparent cause. If the pus do not find ready exit, rapid extension of the disease may take place and new parts be involved in the necrosis. Thus it may happen that necrosis, originally limited to but a small part of laminated texture, may ultimately involve not only the whole thickness, but almost the whole extent of a bone.

Although the sequestrum becomes completely detached from the living bone, it is not necessarily loose

and movable. It may be held firmly in its position by the tight embrace of the cortical formation thrown around it by the periosteum, or even by fibrous, cartilaginous texture, or by granulations which have shot into the interstices of the cribriform parts, thus as it were nailing it down firmly. Most frequently, however, so soon as the sequestrum is detached, it is more or less movable when pressed upon by probe or finger. If then not removed by art, as it should be, it makes its appearance, or attempts to do so, at the surface, and projects, becoming black from exposure to the air. If the sequestrum be not removed at the proper time, inflammation is again lighted up, and the substitute or new bone, being of feeble vitality, may perish, and thus all that has been gained will be lost.

One of the greatest difficulties the surgeon has to contend with is that of anticipating the *time* to be consumed in the various stages from the commencement to the termination of the complicated process which leads to necrosis from the incipient inflammation. It is extremely variable. In acute external necrosis, of very limited extent, but a few days may be required; when more extensive, weeks may elapse; and, if the whole thickness of the bone has perished to a considerable extent, many months are usually consumed ere the bone is released, and quite as much time may then pass before the limb resumes its form and function. Where relapses occur, the course of the disease may be prolonged indefinitely for years. In spongy bones, on account of their greater vascularity, the process is ordinarily more rapid than in the dense. The bones of the upper extremity usually require less time than those of the lower.

Vidal de Cassis gives from one to six months as the limits for the death and detachment of bone, and this answers well as a general rule. The same general laws, however, govern the inflammatory process in bones as in the soft parts. In soft parts, the leg particularly, we see ulcers become indolent and chronic, and run on for years; the same thing occurs in ulceration and in necrosis of bone; the diseased action becomes fatigued, exhausted, and, like an old ulcer, remains stationary for an indefinite time.

"The exfoliation of bone is an uncertain process in respect to the rapidity of its progress; nor can this always be explained by the circumstances of the age or health of the individual: for, in some instances, the process advances more actively in old than in young persons; in those of feeble health than in others of robust constitution. There are also instances of necrosis in which separation of the dead bone *never commences*; and other instances in which the process, having commenced, is, without appreciable cause, arrested in its progress. The following is an instance of the latter kind. Amputation of the thigh was performed thirty-five years after the fracture of the femur, which had been followed by an abscess in the soft parts, and the formation of a fistulous passage in the walls of the bone, which was still open at the time of the removal of the limb. A section of the femur discovered a small portion of its inner wall of a dark-brown color, and in part exfoliated. Here, therefore, it appeared that a portion of the inner wall of the femur having perished, its exfoliation was but in part effected: it had retained its connection with the living bone, and through the long period of thirty-five years had been the source of suffering, which at length induced the patient to solicit the removal of the limb. That dead bone may thus retain its connection with living bone for an indefinite period, is an important fact, as it bears upon the question hereafter to be considered,—under what circumstances operations for the removal of dead bone may, with propriety, be undertaken. * * * *

" Instances of necrosis in early life have occurred, wherein

a small portion of dead bone, not separated from the living bone, *has remained unchanged for many years, and the fistulous passages in the soft parts leading to it have become closed.* Under these circumstances, the patient has presumed upon the sound condition of the parts; but after the lapse of some time, it may be a year or more, a fresh attack of inflammation, followed by abscess and the reopening of the fistulous passages, has shown the original source of irritation still existed. But the complete cicatrization of the soft parts over dead bone, however small its extent, is a rare occurrence, and it probably occurs only in instances where the separation of the dead bone from the living has failed to take place. When the dead bone is detached from the living bone, it becomes a foreign body, an irritant to the adjacent parts; purulent fluid is consequently formed around it, the outlet for which is the fistulous passages in the surrounding soft parts. So long, therefore, as this suppuration continues, the fistulous passages are sure to remain open. But, on the other hand, a small piece of dead bone, retaining its connection with the living bone, may excite so little irritation in the surrounding parts, that no suppuration from them ensues, and, under such circumstances, it is not unlikely that the fistulous passages leading to the dead bone may become closed."

I can vouch for the accuracy of Mr. Stanley as to the facts and principles laid down in the foregoing extracts, and could fully corroborate them by cases of my own, were it not for transcending my prescribed limits.

It is remarkable how long foreign bodies will often remain buried in the tissues without producing any apparent irritation. I recently removed from an eyeball a piece of copper percussion cap, which had been buried in it for four years.

A short time ago I removed a small splinter of pine wood from the cheek, where it had been encysted twenty-seven years; and a few years ago I opened an abscess of recent formation, on the buttock of a Ger-

man, and out dropped a ball, which had been there since the battle of Austerlitz, about forty years.

Treatment.—As remarked, when speaking of *caries*, prevention is better than cure. The preliminary ostitis should be promptly met and treated, to guard against the destruction to which it leads. After suppuration has taken place, and necrosis is actually progressing, we must watch patiently, combat symptoms, and assist the process of repair. A prominent indication is to evacuate the pus as soon as formed.

"Time, texture, and torture may all be saved, by an early, free, and direct incision, which should be practiced as soon as the indications of suppuration are sufficiently manifest.

"*Detachment of the sequestrum we commit entirely to nature*; contenting ourselves with overlooking her operations, and taking especial care that she shall not be interfered with. With this latter object in view, the part is kept quiet, used as little as possible, and not put in the way of external violence. By some exercise of the affected part is enjoined, with a view to expedite the separation of the dead portion, when that seems to be unreasonably slow; but, to my mind, the practice seems fraught with danger, as regards aggravation and extension of the disease, by inducing excess of vascular action. Should inflammatory reaccession at any time threaten, leeches, fomentations, absolute repose, and general antiphlogistics, if need be, are at once employed, with a view of its speedy arrest. On this account also, during the chronic stage, when perhaps purulent secretion is great, and hectic is either threatened or fully developed, and when, consequently, we are anxious to support the system in its difficulties—that support must be prudently conducted, and made to vary from time to time, as circumstances may demand, in order to avoid its being the cause of local overaction."

So far, operative surgery has little excuse for interference; but when the sequestrum is completely detached, *nature's* part is over, and we are then called

upon to do ours. The power of nature, though admirable up to this point, is of little avail in the extrusion of dead bone, and the system is exhausted by long and painful efforts.

The neglect to aid nature at the proper time is one of the great errors of practice, but one perhaps still greater, is the attempt to remove the sequestrum *before it is loose.*

"To lay hold of it then and use violence, after exposure by incision, is certainly to induce a combination of evils. The evulsive effort fails, and, consequently, the patient has been put to a grave amount of pain unnecessarily and fruitlessly. By the violence, inflammatory reaccession is certainly induced in and around the part originally implicated. In other words, a fresh ostitis, probably both acute and extensive, is induced, and aggravation of the necrosis is most likely to follow. Also the loss of blood, that attends such attempts, whether successful or not, is invariably considerable; coming from a wound of soft parts, which are not only unusually vascular, but besides unfavorable to natural hemostatics, as formerly explained. Moreover, the condition of the patient in the advanced stage of necrosis is such as to be altogether intolerant of a repetition of such hemorrhages."

Therefore, until the process of separation is completed, it is the part of the surgeon to watch patiently; to guard against too much inflammation; to regulate the action of nature as far as possible, both general and local; and to forbid any motion which might bend or fracture the weakened bone.

By probing from time to time, we ascertain the condition of the bone, and sometimes we are much facilitated by using two probes simultaneously; thus pressing the sequestrum at two points, we are more apt to detect motion.

If the shaft of a long bone be separating in its entire

thickness, and to a considerable extent, it is all-important to keep it well supported and immovable, to guard against bending, fracture, shortening, injury of blood-vessels from spiculæ of bone, etc.

But when the sequestrum of bone *has* become loose, and not before, it is the duty of the surgeon to remove it promptly, if in an accessible part. An incision sufficiently free to get well at the part to be removed should be made down upon one of the cloacæ, and the condition of the sequestrum examined. If the natural opening in the cortical portion is not sufficient for its removal, it should be enlarged by trephine, gouge, or bone nippers, and a strong pair of forceps should be introduced, the dead bone seized, and, by steady motion, pulling, twisting, etc., be extracted.

While, on the other hand, it is indispensable that the opening should be sufficient for the extraction, it should be remembered that as little as possible of the new bone should be sacrificed, for, once removed, it will not be reproduced, and the limb, in consequence, may be permanently weakened and deformed. Strong, narrow, long forceps are constructed, and are convenient for such operations; but I have often used, with excellent effect, common tooth forceps, a little curved—their firmness of grip and power are well illustrated in the extraction of a molar tooth. Where the sequestrum is long, the operation is much facilitated by cutting through its center with bone pliers.

It has been supposed that dead bone may, by contact with pus, by the action of absorbents, or both combined, be disintegrated, taken up and removed from the system through efforts of nature alone. But this is now known to be a mistaken idea. Ulceration and disintegration may

take place in *living* bone, or absorbents may act on living bone; but when a part is fairly thrown off from its attachments, it becomes a foreign body, and is no more under the control of pathological or physiological action, than a piece of wood or porcelain. Such is the pathological doctrine now universally taught, and yet I have seen cases during the war in which I could explain the disappearance of dead bone on no other principle than that of absorption.

After the sequestrum has been removed, the wound should be stuffed with lint, covered by a compress and bandage, to arrest hemorrhage, and the antiphlogistic treatment enforced. The lint dressing should be continued, in order to keep the wound open, and to force it to fill up from the bottom. It should be remembered that when the sequestrum is removed, the substitute is *hollow*, imperfect, weak, and prone to give way, even from its own weight. The part should be kept in perfect rest until the wound is entirely healed, and then it should be well supported by binders' boards and starch bandage before the patient is allowed to get up. It may even then require months before a leg or an arm can be safely used, to perform its accustomed functions. During the whole treatment, both before and after the separation and removal of the sequestrum, it is important to look to the condition of neighboring joints, which, from long inaction, become ankylosed; to guard against this, passive motion should be used from time to time.

In the cranium, superficial exfoliation, involving a layer or the whole thickness of the external table, is common, both from injury and disease; and the dead leaf may seem firmly fixed, even after all connection

with the living parts is cut off. This cannot be by cortical formation, for in the cranium this is seldom if ever produced. It may be the result either of redundant granulations or of atmospheric pressure. Granulations not unfrequently spring profusely from the margins of living parts, and overlap the plate of bone, so as to hold it in place like the crystal of a watch; or the plate of bone lying flat on a bed of granulations may fit so closely as to be held in place by the atmospheric pressure of fourteen pounds to the square inch. In either case, one edge should be freed of its coverings, and an elevator inserted beneath, when it is easily raised from its bed. Although amputation is sometimes demanded for the relief of necrosis, this is the exception to a general rule.

In young subjects particularly, the symptoms, local and general, are so violent that it becomes evident that the patient cannot abide the time necessary for the tedious process of nature, and we must amputate to save life. There are also chronic cases, where suppuration, hectic, etc. are going on for months, without prospect of the sequestrum being thrown off in time, in which we must take the choice of evils and remove the limb, while the patient has still strength to stand the operation. Nature, in some of these cases, is utterly incompetent to the amount of work required, together with the long wear and tear of the system; and the first consideration is *life*, which can be saved only by timely and decisive action.

PART II.

As before stated, what I have said in Part I. respecting injuries of bones, has been mainly a *résumé* of those *general* pathological principles and rules of practice which may be considered as the matured opinions of the present day; reserving any peculiar views I may have, resulting from my own experience, to Part II. of the essay.

It will be remembered that I have intentionally passed by those specific forms of disease, scrofula, syphilis, etc., which belong more to civil than military practice, and which are well treated in systematic works on surgery. Recruits laboring under these diatheses, or forms of disease, do not come much under the eye of the army surgeon, as most of them are rejected, or if received in service, break down early, and are discharged before getting into battle. It is therefore, I repeat, *simple* inflammation and its consequences that I propose to consider. Having, during and since the war, been called on to treat a large number of both acute and chronic injuries of bone, many of them of several years' duration, and having, from the want of medical literature in this department, been obliged to a great extent to make out my own rules of practice, I hope I may be able to supply some useful hints to younger surgeons.

After being connected with the army, and seeing a

good deal of field surgery from the first battle of Manassas to the close of General Bragg's Kentucky campaign, I resigned my position on the general's staff and retired to private practice in Mobile. Few surgeons of the South, during the last two years, have seen as many of the class of cases, of which I am treating, as myself. I have not only taken an active part voluntarily in the surgical work of some half a dozen hospitals in Mobile, but have been consulted by many from the interior of Alabama, Mississippi, Florida, and other parts, in my private practice, who have been victims of the various battle-fields of the war.

These cases all come with suppurating wounds, the discharge being kept up by retained balls, fragments of shells, pieces of clothing, and other foreign bodies, but by far the greater number have received some injury of the bones, and necrosed or detached fragments cause the trouble. In some, nature has long since completed her work, and thrown off the condemned portion of bone; while in others, from neglect, imprudence, and other causes, the diseased action is still going on and necrosis extending.

Most of these patients have been seen and treated by surgeons of no experience in this class of cases, and little or nothing has been done for them, although relief might have been afforded long before they were presented to me. A man comes who has had a minié-ball passed through the arm or leg, striking a bone, and either simply contusing its surface, and perhaps knocking off the periosteum, or fracturing and splintering it. In a few instances, perhaps, the surgeon has, in the confusion of the battle-field, cut down upon the shattered bone and removed the detached fragments, but more

frequently the patient has been in the hurry sent off to some distant hospital without anything having been done and the time passed for *primary* operations. In either case, the patient eventually comes to me at the end of two or three months, or more, and not unfrequently after the expiration of one, two, three, or even four years (I have very recently operated on one, wounded at the first battle of Manassas, and am now writing in July, 1865); and he comes with one or more fistulous openings, discharging pus.

Now, when such a case presents, what is the first conclusion arrived at by the surgeon on simple inspection? It is simply this, that the suppuration must be kept up by dead bone or other foreign body.

Can any general rule of practice be laid down for such cases? The great difficulty is not so much to determine *what* should be done, as *when* to do it. The rule I adopt, and I think it a very important one, is, to *cut down and search for the offending body as soon as circumstances will permit*, as recovery cannot take place until it is removed. But what are the circumstances that should guide our course?

The following are the most important considerations: *First*, if there is much inflammation and swelling, with a baggy feeling, and particularly if the inflammation presents an unhealthy or erysipelatous character, the knife should be withheld, as its premature use will be followed by increase of inflammation, suppuration, ulceration, and probably sloughing, with corresponding constitutional disturbance. *Second*, the process of exfoliation or separation of the dead from the living bone may not have been completed, and we have already laid down the rule, that no operation should be attempted

before the detachment is complete. Now comes the important point; how are we to determine the actual condition of the bone? Has or has not the sequestrum been detached? Frequently the probe skillfully used will determine the question, but in spite of all that books say on the subject, there are many cases which the probe alone will not decide. A probe passed through a small, and often long and circuitous channel, may fail to reach dead bone at all, or if it does, we may not be able to determine whether it is detached or not. The dead bone is not unfrequently so bound down by surrounding granulations as to be immovable. It will not then be safe in all cases to wait until we can feel loose bone.

The study of bone pathology of gunshot fractures, where the inflammation is *simple*, and the constitution uncontaminated by specific diseases, or not complicated by typhoid disease, will show that exfoliation goes on rapidly, and that in the majority of cases in the long bones of the upper and lower extremity, two to four months are sufficient for nature to do her work, and to hand the case over to the operative surgeon. In the small bones of the fingers, those of the metatarsus, and the radius and ulna, a month or six weeks is often sufficient.

My general rule, therefore, has been this; if a patient comes to me two, three, four, or more months after a gunshot injury, with a fistulous opening (unless such a procedure be distinctly contraindicated by an inflammatory, unhealthy condition of the part, or unfavorable condition of the system), I cut down boldly in the direction of the sinus, laying it open to the bone, and then introduce my finger and explore it fully so as to ascertain certainly what is the condition of the bone,

and whether I am justified in removing the dead portion. A clean, incised cut, under these circumstances, does no harm, and it enables us to obtain at once the information wanted. If the bone is not detached, close the wound and let it heal, as it often will, by first intention, without giving the patient any inconvenience.

In the majority of cases I find balls, clothing, fragments of bone, or other foreign body, and the patient is relieved at once by its removal. In others, the exploration is unsatisfactory, particularly in fleshy parts, as the thigh and shoulder, where the bone is thickly imbedded in the muscular and other tissues, and also in complicated anatomical structures.

The foreign body is sometimes in a very different position from that expected by the surgeon; a ball, for instance, having been diverted from its course, or having burrowed off from its original site.

I would ask the reader's attention to the following extract from the work of Baron Dupuytren, entitled "*Traité des blessures par armes à feu.*" It is well expressed and full of instruction.

"The local symptoms, in wounds from balls fracturing bones, result principally from the presence of splinters, which act the part of foreign bodies; they are of different kinds, and require special notice. I divide these cases as follows: 1. *Primitive Splinters*, that is to say, those which have been completely separated from the bone and soft parts by the projectile at the moment of the injury; they are entirely detached. 2. *Secondary Splinters*, which are not completely detached from the bone and soft parts, and which cling to the latter by tendinous, muscular, or ligamentous bands. These splinters are eliminated by suppuration, at the end of very variable periods; eight, ten, fifteen, twenty, thirty, or even more days. 3. *Tertiary Splinters*, that is to say, those that result from the contusion of bone by projectiles, in the parts which surround the

point of fracture, and which nature produces by virtue of a peculiar morbid process; a process ordinarily very tedious, and which sometimes will continue for ten, fifteen, or twenty years. Thus, for example, we saw at the *Hôtel Dieu*, in 1830, an old soldier affected with tertiary splinters, caused by a gunshot wound received in 1813.

"When a bone has been fractured by a ball, it sometimes happens that the contused bony extremity becomes necrosed and detached at the end of some weeks or months, and then the fracture may consolidate. At other times the necrosed extremities" (instead of being pushed aside) "remain *in situ*, and the two ends cannot unite; a *provisional* callus forms around them, and gives them a certain solidity; but the *definitive* callus never forms—the *provisional* callus alone envelops them, becoming hard, and incloses in the center of its substance the dead parts, which thus represent a true *sequestrum*. The sojourn of these tertiary splinters in the midst of callus is one of the most common causes of deformity, and endless fistulas. In some cases, not even *provisional* callus is formed, and it is not till after the detachment of the necrosed parts, that the consolidation takes place. This division of splinters into primary, secondary, and tertiary, is of the greatest importance—each one demanding particular treatment. Thus the *first* should be removed *immediately*—the *second* in the majority of cases should not be removed until their extraction would be free from the danger of hemorrhage, severe pain, and only after they have been more or less completely detached by suppuration. As to the *third*, they should not be removed before nature has completed her work of elimination; and, as we have seen, this period cannot be fixed with precision."

The three classes of cases have been presented to me in considerable numbers, and both the arrangement and the precepts of the Baron strike me as being eminently judicious and practical.

Now there is an important practical point involved in many of these cases, which has not been fully met by the Baron, and which is too important to be passed over. By way of illustration, suppose a minié-ball

strikes the shaft of one of the long bones, passing through and fracturing it—what is the usual condition of the bone in such cases—what does observation teach us to expect? The bone is not only fractured completely across, but it is splintered up and down more or less, and sometimes for several inches, and the question arises, to what extent should we attempt to remove these fragments?—should *all* the fragments detached from the shaft be immediately removed? Now, I confess that I have adopted, in the latter part of the war, very different practice from that followed at the beginning. Surgeons have generally become more conservative. In the first place, we now amputate much less than formerly, and not only save more limbs, but more lives, by avoiding amputation and trying to save the limb. In the next place, I am much less scrupulous now than formerly in leaving fragments *in situ*, and have been astonished at the manner in which nature would solder them together. Those fragments which are knocked entirely loose from all attachments should be removed as soon after the injury as possible. The finger should be passed into the wound and made to explore the parts fully, and all the small fragments that are out of place, and movable, should be taken out. The finger will, however, detect longitudinal fractures, or pieces of some size split off, but *remaining in apposition with the mother bone*, covered with periosteum, and attached to the neighboring soft parts and receiving nourishment from them; now such pieces should *not be removed*, they have all the elements of vitality and will become firmly consolidated if left, and carefully managed by absolute quiet, antiphlogistics, etc. Their removal would be attended by a degree of violence to the soft

parts, which, added to the injury already done by the projectile, would result in painful and dangerous inflammation and suppuration. If nature should fail to consolidate the fragments, they will be cast aside by suppuration, and may be removed with less danger by a secondary than primary operation, some weeks later.

How many limbs have been saved during our war, by this conservative course?

It is always an important, and often exceedingly difficult point, in the *second* and *third* divisions of Baron Dupuytren, to determine *when* to operate; if too soon, we aggravate the disease and increase the difficulties and danger; if we defer too long, the constitution becomes worn, the disease extends beyond its wonted limits, and callus, in excess, is thrown around the dead bone, rendering its removal difficult and often impossible.

How are these difficulties to be overcome? what rules of action have we? It must be confessed that the cases are so varied and complicated as to defy general rules, and experience alone must guide. Most of the difficulties may be satisfactorily met by the experienced practical surgeon, while others are involved in so much obscurity that a Dupuytren or a Guthrie would be at a loss for a clear rule of action.

Where we have to deal with *external* inflammation and its events, nature is working before our eyes, we are enabled to direct her operations, and give efficient aid at the proper time; a fragment of bone is here thrown off from its attachments, in full view, and we have nothing to do but take it away with a pair of forceps from the surface. But where the process of exfoliation is going on in an injured bone, deeply

buried beneath soft parts and encircled by complicated anatomical structures, much must be left to conjecture as to the actual condition; and the ablest surgeon may interfere too soon or too late. Our embarrassment is greatly increased by the fact that the work of nature does not always progress at the same pace. Necrosis in one case will involve but a superficial leaf, or small portion of the entire thickness of the bone, while in another it progresses from point to point, involving a larger part, or even the entire shaft; and it often happens that we cannot determine whether necrosis has terminated, or is still progressing; and whether the destruction of bone be great or small, the time consumed in accomplishing a similar result varies greatly in different cases. This variation depends on an infinite number of circumstances, which often we can neither comprehend nor control; such as original peculiarity of constitution, specific taints, as scrofula, syphilis, etc., bad air, bad diet, badly placed spiculæ of bone, depressing moral influence, etc., etc.

The pathology of bones is in itself a difficult study, but no inconsiderable light is thrown on the subject by watching through all its stages, necrosis, in those superficial bones which are often exposed to view by injuries. We witness every step of the morbid process, and are enabled to infer, from what we see in the superficial, what takes place in the deep-seated parts.

Owing to the predominance of earthy matter in bones, and their lesser vascularity and sensibility, inflammation is considerably modified in this tissue, but still the general laws governing the hard and soft tissues are essentially the same. Bones are subject to inflammation, simple, specific, acute, and chronic. They suppurate,

but with more difficulty than soft parts; while on the other hand, they soften and lose vitality, often, from apparently slight causes, and under low morbid action. Inflammation in soft parts leads readily to suppuration, and not unfrequently results in large abscesses; while in pure osteitis, on the contrary, pus is rarely seen in any form, much less in that of abscess. Bones inflame with difficulty, but when inflammation fairly sets in, it almost invariably leads to structural disorder, resulting sooner or later in necrosis.

Bones too when wounded, or divided, heal by the same process as soft parts. In a simple fracture, if the parts can be placed in perfect apposition at once, and there retained, they heal by immediate union very much as soft parts do. When close apposition is not attainable, lymph is thrown out between the fragments, and this becomes gradually organized, and transformed into kindred bony tissue, uniting much in the same way as tendon, muscle, or other soft structure. In compound fractures, where suppuration and ulceration are brought into play, the fragments unite by granulations, which in turn become consolidated into bone.

I shall now bring before the student the rough sketches of a few cases, which may serve to give a more satisfactory idea of the morbid process I wish to illustrate.

I had, some months ago, a young soldier, just recovering from frost-bite of the feet, received in the Tennessee army; and another, at the same time, in whom the toes had been much contused by the wheel of a caisson. The progress of disease in the two, and the results, were almost identical. The vitality of the soft parts in both, to about midway of the several toes, was destroyed,

and periostem and bone, in both cases, more or less implicated. In both, the soft parts mortified and sloughed off to the extent of the injury, leaving the naked phalanges projecting and exposed to the air. Owing to the greater vascularity of the soft parts, but a few days were required for the formation and separation of *its* sloughs.

The bones having suffered from the original causes, contusion and frost, then being stripped of their coverings (including periosteum) by mortification, and being moreover exposed to the action of atmospheric air, *their* death, like that of the soft parts, was inevitable, and was only a question of time. While in the soft parts a few days were sufficient, in the less vascular tissue almost as many weeks were necessary to complete the morbid process. After the soft coverings of the bones were removed by sloughing, from loss of circulation, they first turned white and then almost black from the action of air.

In the soft parts the extent of the injury was soon determined, and at the end of four or five days a line of demarkation was established between the dead and living parts; and while the circulation was disappearing from the dying part, the living was becoming more vascular, for the reason that it was called upon not only to maintain its own existence, but to repair, to a certain extent, the injury done. The absorbents now came to the rescue, having an important part to play; they went to work, at the line of demarkation, to separate the dead from the living portion, and to cast off what was useless and an incumbrance; in a few days this was accomplished through their agency. As the absorbents cut deeper and deeper from the surface

toward the bone, leaving a dead wall on one side and a living one on the other, the latter became covered with healthy granulations, ready for the work of repair; and soon a new skin was seen gradually forming from the margin of the old, and extending over the granulations.

All this being completed, we next watched, with interest, what transpired in the bones, and observed the process here to be identical with that which had taken place in the enveloping soft parts, only requiring weeks instead of days for its completion. In the bone, inflammation, suppuration, ulceration, and sloughing were but repetitions of what had occurred in the soft parts. The dying portions of the bones gradually lost their vascularity, while the living increased in vascularity, and the absorbents, *pari passu*, separated the two. When the absorbents had completed their work, and the dead bone become detached, I took a pair of forceps and lifted it off, leaving the living bone from which it had been removed, raw, bleeding, and covered with healthy granulations; the end of the bone having lost all appearance of the original tissue.

The next step in the process was the extension, over these granulations, of the skin which had already covered the soft parts up to the margin of the bone. The work of reparation was now finished, and nature was seen in these examples, as she always is under like circumstances, to have performed a complete *amputation*.

The amputation in the different toes required from three to six weeks, according to the degree of contusion, the rapidity of the mortification, and the size and compactness of the bone involved.

Had I seen early the patient in whom the injury was

the result of contusion by a caisson, before severe inflammation commenced, much time might have been saved by amputating the toes; the nature of the injury was such, that it was evident the parts involved could not be saved, and by amputating high enough to reach sound tissues, good stumps were attainable, and the cure certain and speedy. After, however, severe inflammation and swelling set in, it is better not to interfere till nature has exhausted her resources. In cutting through inflamed tissues there is always danger of giving extension to the gangrene.

In the frosted foot, on the contrary, the case was best left to nature, who alone could determine the extent of the injury, and where the *line of demarkation* would be established.

In a third case, now under treatment in one of the military hospitals in Mobile, the patient accidentally shot himself in the hand with a pistol. The palm of the hand was resting on the muzzle, when it exploded; the ball passed obliquely through, coming out at the back of the hand, fracturing and shattering the metacarpal bones of the middle and ring fingers. In consequence of the shattering and violence of the explosion, the back of the hand was much torn, high inflammation followed, with sloughing to the extent of a dollar, leaving the ragged ends of the bones exposed to view. At the end of three weeks, healthy granulations began to appear, the slough having separated, and the jagged ends of the bones began to be thrown off in small fragments; while the compact shafts, seen deep in the wound, were white, non-vascular, and firmly adhering to the rest of the bones which were covered by soft parts. Here it is evident that a portion of the

bone is dying, but in a wound still suppurating freely, it is impossible to say how far necrosis will extend. Generally where the extremity of a bone undergoing necrosis is exposed to view, we can, at the end of three or four weeks, determine pretty satisfactorily where the line of demarkation will be established, by running a probe gently along its surface from the extremity up under the superimposed soft tissues; the probe glides along the naked, smooth bone, till it is stopped by granulations sprouting from its surface and adhering to the surrounding tissues. Here we have proof positive that the bone is living at that point, and here is the point where the dead bone will separate from the living. The bone usually does not die in *all its thickness* up to this point, but throws off, in most cases, a cap or thimble-shaped exfoliation.

With regard to the case above alluded to, all I know positively is, that the ends of the bones are dying and passing through the process of necrosis already described, and thus, in a week or two more, nature will complete the work of separation, and that she should not be interfered with till the sequestrum is fairly detached. When the dead bone is removed by forceps, granulations will sprout up, and a firm cicatrix soon close the chasm.

It is not uncommon to see the end of the bone exposed, after amputations, either from insufficiency of flap or from unavoidable sloughing of the stump. Here we have an excellent opportunity of studying the process of exfoliation; a portion of bone dies and is gradually cut loose by the absorbents and thrown off. Sometimes it is a little scale, not larger and thicker than the thumb nail, and is liberated in fifteen to thirty days,

leaving healthy granulations. I have seen three stumps, two below the knee, and one in the middle of the thigh, within the last few weeks, in which this has occurred; the largest fragment, that of the femur, was half an inch wide, quite thin, and covered half the circumference of the bone at the sawn extremity; those of the two tibiae were smaller, and took about the same time to separate.

In amputations where there is abundance of flap, with imperfect adhesion, followed by copious suppuration of the stump, from amputating through unsound tissues (as in secondary amputations), or from constitutional disturbance,—I say in such cases, where the bone becomes diseased, and necrosis follows, the process is usually slow, and of very uncertain duration; frequently several months pass before the sequestrum is severed from the living bone. The surgeon, in such cases, must be patient, pass a strong probe or director from time to time to ascertain whether nature has completed her work, and, when she has, he should lose no time in cutting down and removing the loose bone. Forty to sixty days will generally complete the process, but I have sometimes been obliged to wait many months. Here, as in suppurating gunshot wounds involving bones, the course the diseased action takes, as to time and involvement of adjoining parts by continuity, depends upon the *character* of the inflammation. Healthy pus will burrow around the periosteum of a bone or ligaments of a joint without implicating either, while a very different result follows the contact of *unhealthy* pus. Where the discharge is fetid and ichorous, it is very irritating, and its contact with healthy bone will first implicate the periosteum, then the bone, and may thence extend along an entire shaft. Whenever I see a pallid,

ashy hue of the lips of a stump, with a baggy, swollen condition of the flaps, thin ichorous discharge instead of thick laudable pus, together with quick pulse, feverish thirst, occasional sweats, etc., I always feel alarmed, expecting the spread of disease along the shaft of the bone, and even danger to life from hectic fever, and perhaps pyemia.

In those cases where the bone projects from the stump, the inexperienced surgeon is often tempted to interfere, not only unnecessarily, but injuriously with the operations of nature. I have been often consulted to know whether it is not best to saw off the projecting bone; but though a contrary opinion has recently been advanced by an army surgeon, I unhesitatingly say *no*. Where a bone projects from an open, suppurating stump, under any circumstances, it will require at least a month, and probably six or eight weeks, before the stump can be healed, whether the bone is on or off. Experience teaches that nature will amputate the bone, and generally at a very good point, by the time the rest of the wound closes up to its margin, and thus do away with the necessity of amputation by the surgeon: the absorbents set to work, at the line between the dead and living bone, and in from four to eight weeks, the work is complete, and the skin soon closes over it.

If while a stump is swollen, inflamed, and suppurating freely, the surgeon cuts down to remove a projecting end of bone, he adds to the inflammation, causes more or less hemorrhage, shocks the system, makes the condition of the stump altogether worse, and *gains no time* in the final result, even if the case does well. One of the greatest objections to the operation is the danger of

extending the necrosis, by exposing a fresh surface of bone to unhealthy pus of the stump. This must necessarily be the most common result; the projecting bone to be removed dies because it is exposed to air and pus, and the surface exposed by the second operation is likely to be followed by similar result, from the same causes. We have already laid down the general rule, that no attempt should be made to remove a *seques-trum* before it is completely detached, and the same rule applies to these stump cases.

There is, however, sometimes a sequel to some of these cases, that requires surgical interference. It happens, where nature has performed the amputation of the projecting bone, and the soft parts have completely covered it over, that a *conical stump* results, and the end of the bone being covered merely by a thin cicatrix of new skin, it is tender, easily chafed, or hurt by slight injuries, inflames, sometimes ulcerates, is troublesome in various ways, and particularly if an artificial limb be worn. In such cases, the conical form of the stump is increased by the retraction of the muscles, and it thus becomes quite pointed. Under such circumstances, it is often good surgery to cut down upon the projecting bone, detach freely its coverings, and saw it off an inch or two within the soft parts, when a rapid cure usually follows. Here we are operating on tissues, all of which are sound, and union by first intention ensues.

With the view of farther illustrating principles of practice, I will give a few abstracts of gunshot wounds treated during the war.

Case A. was that of the gallant General Gracie, since killed at the siege of Petersburg. He was wound-

ed in a skirmish at Bean's Station, in Tennessee. He was struck by a musket-ball on the forearm, about two inches below the elbow-joint, the ball entering from behind, grazing the ulna, passing transversely, deeply below the flexor muscles, and coming out in front of the radius. He came to Mobile, and called on me to examine the wound, stating that his surgeon had pronounced it a simple flesh wound, which would be well at the end of his thirty days' furlough. The parts around the track of the ball were much inflamed, swollen, and evidently in the process of suppuration. This was about twenty days after the receipt of the injury. I gave at once, as my opinion, that the periosteum and bone had been *contused*, that exfoliation would follow, with troublesome abscess; and that at least three months would be required for the recovery of the use of the arm. The little and ring fingers were also paralyzed. The inflammation progressed and two abscesses formed, one near the entrance of the ball and the other on the back of the arm between the radius and ulna. At the end of six weeks, the one near the entrance of the ball was opened and several small pieces of *exfoliated bone* removed. A week later the other abscess was laid open freely through the fascia and discharged a gill of pus. The two abscesses now closed from the bottom and the case went rapidly on to cure. There was great enlargement of the forearm from deposition of lymph, which, together with the paralysis of fingers, was rapidly disappearing when he returned to his command two months after the injury. He wrote me afterward that his recovery was complete.

Now the point in this case I wish to impress on the mind of the student is the effect of *contusion* on bone.

My experience leads me to believe that contusion is often quite as bad or even worse than a gunshot fracture. When a ball grazes a bone in this way and passes out, the track of the ball often heals and closes before the mischief in the bone is fully developed; the disease of osseous tissue works slowly, and after the soft parts have closed, the inflammation of the bone results in abscess and necrosis, and having no exit, much mischief is done by burrowing of matter. Where the bone is broken by the ball, a compound fracture is made, the wound remains open, there is free exit for pus as it forms, and the disease is less likely to extend.

The surgeon who first treated the case of General Gracie passed his finger into the wound, and finding no fracture or splintering, concluded that it was only a flesh wound and would soon close, and this opinion in many cases would have been justified.

When the spongy extremity of a long bone is struck and contused by a projectile, even where there is no break of periosteum, I have seen considerable extravasation of blood into the cancellous structure; and in the case of General Deas, who was struck on the knee by a spent musket-ball, at Shiloh, though there was no break of the skin, he had serious inflammation of the joint, from which he recovered with difficulty. I have seen many similar joint cases.

Generally speaking, the contusion of a bone by a projectile causes inflammation of periosteum and bone, and the latter dying *gradually*, finally exfoliates. On the other hand, where the blow is sharp and violent, the contusion is sufficient to kill a part of the bone outright; the living parts around increase in vascularity, and the dead part by a vital process is gradually thrown off.

In these cases of contusion, it not unfrequently happens that the *concussion* is communicated to the *medulla* in the long bones; it is torn, its blood-vessels ruptured, blood is extravasated, and destructive inflammation may be set up, followed by internal necrosis. Where a long bone is fractured by a minié-ball, this injury of the medulla by concussion is not unfrequent; the shaft of the bone even is often split for four or five inches.

B. was a soldier of the army of Virginia, whose radius had been fractured, about the junction of the lower and middle third, *twenty months* before I was consulted. I found, on examination, a considerable enlargement of the bone, extending up and down between four and five inches, with a fistulous opening on the anterior aspect. On introducing a probe, which reached the interior of the enlargement, dead bone was detected. I cut down upon it, and discovered that the shaft of the bone had been shattered, and no operation ever having been performed before, all the fragments, except several small ones which had been floated out by the pus, were still *in situ* and inclosed in a cortical formation, leaving a single cloaca. I removed as many fragments as could be heaped in the bowl of a tablespoon. Some of the fragments were splinters knocked off by the ball at the time of injury, while others were exfoliations from the ends of the bone, caused probably by the irritating presence of the splinters and the consequent suppuration.

The work of reparation then went on rapidly, and the cavity was soon filled up and permanently closed.

This was a very common and simple type of a class combining the first and second divisions of Dupuytren. Many of the fragments had been pent up from the time of the original injury and were gradually incarcerated

by osseous deposit from the periosteum. The indications were clear, and still no attempt had been made to meet them. Had these fragments not been removed, the suppuration might have continued for years. If the loose fragments had been removed at the time of injury, the case would have been reduced to a mere compound fracture, which would have healed in six or eight weeks.

C. was a soldier in the army of Vicksburg, and had his thigh fractured, eighteen months before consulting me, by a musket-ball, which struck the femur just below the trochanter, on the outside, and came out at the opposite point on the inner side. A number of fragments were removed by a field surgeon soon after the injury, and the fracture was then treated by Liston's splint. The limb was shortened about three inches, but the bone was firmly united. There remained, however, a fistulous opening, which continued to discharge until he fell into my hands.

On examination, I found the scars left by the entrance and exit of the ball, and of several other openings natural or artificial, but all had closed except one small one about an inch and a half above the trochanter, toward the crest of the ilium, which was discharging very freely. I concluded that the suppuration was kept up by dead bone or other foreign body, but could not, by the most careful exploration with a probe, detect anything. This small opening was through the very dense fascia that covers the gluteus muscle, which I laid open freely for the purpose of proper exploration. My finger was passed into a large cavity extending around the trochanter, hip-joint, and up toward the crest of the ilium, the matter being forced to burrow by the fascia above alluded to. I could feel the capsular ligament and pass

my finger all around it. No necrosed or diseased bone could be detected, except one small fragment, *not larger than a grain of Indian-corn*, at the bottom of the abscess, beneath the trochanter, as he lay on his back. This was removed and the wound stuffed with lint, to insure healing from the bottom, and give free exit to the discharges. Very rapid improvement followed, and the abscess soon healed.

I should have mentioned, as an important point in this case, that the patient was much emaciated, greatly prostrated by hectic, night sweats, etc., and his friends thought in a dying condition; he could certainly have lived only a few weeks without relief.

After the abscess closed, fever came on, with the formation of another abscess on the upper and inner part of the thigh. As soon as this was sufficiently mature, it was opened and explored as the other had been, but no foreign body detected. It was treated as the other, and soon healed. This second abscess was doubtless caused by the burrowing of the matter from the first abscess beneath the neck of the bone to the inner side. The recovery of the patient was then so rapid and complete that he gained twenty pounds in a month.

Now this case possesses two instructive points: *first*, it shows how small a cause will produce a large and even fatal abscess; and, *second*, it shows how little periosteum and ligamentous covering of joints are affected by the contact of *healthy pus*. Unhealthy suppuration would have diseased the shaft of the bone, and opened the hip-joint, in all probability.

About the same time I was treating the above case I had on hand another equally remarkable; the subject was Mr. Luzenberg, of New Orleans, a young lawyer of

promise, who had been wounded in one of the battles in Tennessee. A single buckshot entered one hip, and after following a very circuitous route, lodged in the upper and inner part of the thigh of the opposite side; a large abscess resulted, which continued to discharge for several months, and when he came to me he was gradually sinking from the discharge, hectic, etc., and colliquative sweats. The probe yielded no information beyond the existence of an enormous cavity. I made a free opening on the upper and inner part of the thigh; had the good fortune to find the shot lying at the bottom of the cavity, and extracted it without difficulty. He was greatly emaciated, the muscles were contracted so as to flex the thigh on the pelvis and the leg on the thigh, and yet his recovery was rapid and complete. Small balls usually produce little irritation, and it is hardly conceivable how a buckshot should have produced and kept up such an enormous abscess.

D. had his thigh-bone fractured, at the battle of Chickamauga, by a minnié-ball passing through the limb, at the junction of the upper and middle third, five months after which he came to consult me. No operation had been performed for the removal of bone. The ball entered on the outside and came out at the inside of the thigh, and pus was still discharging from both openings. On probing, dead bone was detected on both sides, but I could not determine whether the work of nature was finished or whether necrosis was still progressing. The parts around were in good condition (as my friend General Danl. Adams remarked on his own case, of which I shall have something to say) for "a reconnoissance in force," and in accordance with the rule already laid down, I cut down to the bone on both

sides to ascertain its condition. On either side loose fragments of bone were found, the result both of the original splintering, and of exfoliation of the rough angular ends. The ends of the bones had been smoothly rounded off, were overlapping, and firmly united, and the shaft seemed perfectly sound throughout. The only indication therefore was the removal of the loose fragments. About a dozen small pieces from one to three-fourths of an inch in length were removed. The wounds were stuffed with lint, filled rapidly from the bottom with granulations, and the man was soon perfectly well, with the inconvenience of shortening of the limb to about three inches, which occurred before I saw him.

The foregoing cases involve important rules of practice, and I think are worthy of being remembered by the student. A. is a good example of the morbid action which often follows the simple *contusion of a bone* without fracture and the rule of practice which should guide us. In such cases inflammation should be combated from the beginning, the wound should be kept open as long as there is any suppuration within, and if an abscess form, the earlier it is opened the better.

B. C. and D. are also representative types of a class of cases, in which loose fragments have been allowed to remain about the ends of the shattered bones, easily got rid of by incision, and not incased by cortical formation. When such cases are presented, two, three, or four months after the injury, or at a much later period (as very many are), I repeat, the rule is, if there be little local inflammation or constitutional disturbance, "*to make a reconnoissance in force*," cut down, explore, and remove all loose fragments of bone, or other foreign body; keep the wound open until it heals from the bottom.

The following case is interesting in several points of view, but more particularly as illustrating one I have called attention to, viz., the tendency which bones have to necrosis, when exposed to a suppurating cavity. In this case the loose fragments and rough ends of the bones were sawn off and the arm well dressed with splints, yet inflammation and profuse suppuration followed, involving the distal end of the bone in necrosis which had to be removed.

I saw the case in consultation with Dr. C. H. Mastin, who has obligingly furnished me with the following statement:

"J. H. Taylor, aged twenty-eight years, private in Co. G, 8th Alabama Vols., Wilcox Brigade, had his right humerus fractured by gunshot, in front of the lines at Petersburg, Va., on the afternoon of the 23d June, 1864. The ball entered the arm just above the condyloid expansion of the bone, fracturing the same. On the morning of the twenty-fourth, the regimental surgeon removed, with the saw, the fractured ends of the bone and dressed the arm with a carved splint. Owing to the great pain, swelling, and continued discharge, he was placed on the retired list and returned home. He reached Mobile in September, 1864, and since that date to the 12th May, 1865, he has suffered with violent pain and a very profuse discharge.

"On the 12th of May, he was induced to submit to an operation for the removal of the necrosed bone. A sequestrum two and a half inches in length by one inch in width, with a thickness of half an inch, was removed from the external condyloid ridge. A thick cortical shaft had been thrown around the entire circumference, together with much thickening of the capsule and ligaments of the joint, producing partial ankylosis of the elbow-joint.

"After the removal of the sequestrum the discharge rapidly decreased, and the external wound, together with the sinus leading to the bone, healed in fifteen days. He has now very good use of the arm, which is daily increasing in strength.

"It required considerable force to effect the removal of

the sequestrum which was bound in by the new bone. From appearances I am induced to believe that the sequestrum had not been fully detached, and that the operation for its removal was done at as early a date as was justifiable.

"In this case, from 23d of June, 1864, to 12th May, 1865, three hundred and thirty-three days had elapsed, and since the removal of the ends of the bone to the date of removal of the sequestrum, three hundred and thirty-two days. From his statement I am inclined to believe that periostitis, which resulted in the death of the bone, set in immediately after the 'resection' was performed by the regular surgeon. He tells me he had very great pain, followed by profuse discharge, within a very few days after the operation."

July 15th, 1865.

This case is interesting as illustrating the liability of such cases to necrosis, the difference in time required for the completion of the process, the necessity of removal of the sequestrum, and the promptness of the relief from the operation.

I will now give the type of a class of cases that often present great difficulties and embarrassment to the surgeon.

E. was wounded with a minié-ball about twelve months before consulting me. The ball entered on the outside of the thigh just below the middle, and passing along the posterior surface of the femur, came out on the inside, knocking off some splinters. High inflammation, with profuse suppuration, ensued, involving the tissues around to some distance. When presented to me there was great enlargement and induration, covering nearly the whole of the middle and lower thirds of the shaft of the femur. The outer wound had closed, but the inner one continued to discharge freely. On introducing a probe, dead bone was discovered, but what was its extent, or whether detached or not, were points I could not determine; and in spite of all the books say, I re-

peat that nothing but "a reconnoissance" can determine the true condition of the parts and the practice to be pursued in such cases. This man had been and still was a great sufferer; the discharge was profuse, hectic fever and sweats were wearing him away, and he called loudly for relief at any risk. My belief was that nothing short of amputation could be of any avail, but this would have to be done near the trochanter, and he was not in condition to stand such an operation, and I was not disposed to undertake it. It was therefore determined to make a "reconnoissance in force," as had been done in other cases, and "feel the way."

The anatomy of the thigh on the inside, where the opening existed, and the dead bone was felt, is so complicated as to render free incisions at that part hazardous. I therefore made an incision down upon the outer side of the bone, toward the back part, but failed there in finding any disease or obtaining any useful information. I next made carefully an incision on the inner side, following the fistulous track down to the bone. On inserting my finger, its point passed into a small cloaca, in the cortical formation, thrown out by the periosteum, around the necrosed shaft. There were no loose external fragments, and it was evident that the shaft was necrosed up to about the junction of the middle and upper thirds, about five inches above the cloaca I had discovered. I could feel the dead bone through the cloaca, but it was firm in position, and I had no evidence that it was detached.

The question arose, what should be done next? To afford relief, one of two procedures must be adopted, viz., either with trephine and gouge to cut away a large portion of the *cortical formation*, in order to get at and re-

move the necrosed bone, which might or might not be detached; or secondly, to amputate the limb near the trochanter as first suggested. In the prostrated hectic condition of the patient, neither of these alternatives could be entertained; he would have sunk from the shock and hemorrhage. If the cloaca had been on the outer side of the limb, where the bone is thinly covered by soft parts, and where there is little vascularity, it might have been justifiable to go on feeling the way, a part of the new bone might have been removed and the sequestrum explored; but even that would have been doubtful practice. Not only was there danger from the immediate effects of such an operation, but great danger in removing too much of the cortical formation, of producing a fracture which would have made a hopeless complication in his condition.

I concluded on the whole that it was best to abandon the operation, to keep the wound open, and wait further developments. In the course of a few weeks his condition improved greatly, fever left him, appetite returned, and he was up and going about on crutches. This operation was performed about eighteen months ago, and I see the patient from time to time. The discharge occasionally does not get out freely, and he suffers pain and has fever for a week or two; he then gets better and goes about again. He is constantly talking about amputation, and although in good condition for it, cannot make up his mind to have it done. I do not feel inclined to urge him on the subject, as he leads a pretty comfortable existence as he is, and amputation in the upper third of the thigh is always attended by fearful risk. He is dependent on his labor for support, and may therefore be obliged to submit to amputation, or nature

may in time extricate a sequestrum that can be removed without amputation and without danger to life.

Now this is another good example of *contusion of bone*. A musket-ball knocked off a fragment of bone, which was removed by the regimental surgeon, and it might reasonably have been expected that the case would do well, but the bone was *contused*, extensive osteitis and periostitis followed, resulting in necrosis of a considerable portion of the shaft of the femur, which became completely surrounded by a thick cortical formation. When I cut down I found no loose fragments, and it is reasonable to conclude that *contusion* of the bone was the principal cause of all the subsequent trouble. If a similar extent of bone had been chipped out with a chisel, and consequently without *contusion*, no suppuration or other troublesome symptoms would have occurred.

In relating the symptoms of this case, I stated that there was enlargement and induration involving nearly the whole of the middle and lower thirds of thigh; and when the thigh was grasped it felt as if there was an enormous bone within, one four or five times the normal size.

The young surgeon is almost sure to mistake this enlargement for bony deposit, and in some very rare instances it is so; the enlargement and hardness is from deposition of lymph in the cellular and other tissues, and when cut into it is almost as firm as cartilage.

It will be seen that no harm was done, even in this case, by cutting down and exploring the parts fully. I failed in doing good, beyond gaining positive information to guide my action, but the patient soon regained his previous status. There was no other way of ascertaining the true condition of parts, and I felt it a duty to give the man the benefit of the doubt.

The above case is presented as the type of a very important class of which I have seen many during the war; they are almost endless in variety, and the practice to be pursued depends greatly upon the particular bone involved, the character of the surrounding soft parts, the degree and kind of inflammatory action, condition of constitution, etc. Had the bone involved in this case been one of the leg, arm, or forearm, my course would have been very different. I should have removed, boldly, enough of the new cortical formation by trephine and chisel, to get fairly at the sequestrum, and to remove it with forceps. The superficial covering of soft parts, their lesser vascularity, the little danger of hemorrhage, and the facility of supporting the part properly by splints after the operation, would have fully justified such a procedure; but in the case of the thigh-bone, with the immense thickening and other circumstances detailed, the dangers were too great.

These cases of the thigh are those most calculated to embarrass and baffle the surgeon, and more often render amputation necessary than others, although its dangers in the upper third are fearful.

I will next call attention to another class of cases which are embarrassing and in which it is impossible to lay down very explicit rules of action. They can only be treated well by those who have had much experience, and used it wisely. I allude to those cases in which the long bones have been fractured and badly shattered by balls, the fragments removed, the ends of the bones sawn off, and there has been a *loss of substance to the extent of one, two, or three inches*. Here we have a compound fracture of the worst kind, necessarily accompanied by profuse suppuration, and if union takes place

it is effected by the process of granulation after the lapse of months. Although all the fragments may have been removed by the surgeon immediately after the injury, and the parts placed in the most favorable position possible for union, still the high inflammation and suppuration which necessarily follow, not only retard the work of repair, but often complicate it greatly by causing necrosis of one or both extremities of the sound bone. It has already been stated that an abscess in contact with the shaft of a sound bone covered by its periosteum is fraught with danger; the periosteum first becomes implicated, next the bone nourished by it, and exfoliation to a greater or lesser extent follows. Nay more, the medullary cavity being exposed to the contact of pus and air, endostitis, with internal suppuration, ensue, and death of the inner surface, or entire thickness of the bone, results; the bones having little circulation except what is supplied through the external and internal periosteal. This diseased action sometimes travels rapidly and involves the whole shaft of the bone.

Endostitis would seem to be more common after gunshot wounds than others, and this has been attributed to the violent concussion of the blow, which extends its influence far beyond the actual point of fracture, but still I feel assured that it has been much less frequent in our American war than it is said to be in Europe.

M. Jules Roux, Dr. Valette, Baron Larrey, and others have recently written much on the subject, and particularly in connection with the Crimean war; and from their account osteo-myelitis or endostitis has there been very frequent and fearful in its results. Now this has not been my experience in the United States; these cases occur occasionally, but by no means bear a large proportion to external periostitis and exfoliation.

I will here remark that the climate of our Southern States of America seems peculiarly favorable to wounds. Our surgeons have been writing much on gunshot fractures and the facility with which good recoveries are made. I feel assured that no experience of the Old World can compare, in success, with that of the surgeons of the Southern States, not from any peculiar skill on their part, but from the superiority of the climate. When endostitis does occur, and consequent exfoliation, the case should be left to nature until the sequestrum is detached. Amputation of the stump is rarely justifiable in these cases, nor should disarticulation, as recommended by distinguished French surgeons, be thought of. Where endostitis exists in a shaft, if amputation be performed above, the same diseased action is almost certain to attack the new stump. There is good reason to believe too that endostitis is a common cause of death after secondary amputations. Where an amputation of the thigh, for example, is performed a few hours after a gunshot injury, not more than half a dozen arteries ordinarily require ligature, but if it be deferred two or three or more days, double the number will have to be secured; thus proving the increased vascularity of the soft parts. The bone is influenced in the same way, and its increased vascularity predisposes to endostitis and periostitis. The flaps in secondary amputation hardly ever do any healing by first intention, and are liable to suppuration and gangrene.

But let us return from this digression to that class of cases where there has been loss of one, two, or three inches of bone, and nature is called on to repair the injury, after the surgeon has, as far as possible, removed all impediments, in the shape of detached fragments,

jagged ends, etc. While the suppuration is going on in the interspace between the ends of the bones, these become inflamed and throw out granulations; the whole of the ends may throw out granulations, or the whole of the ends may become necrosed and exfoliate; what is more common, the prominent angles and edges are thrown off, while the rest granulates, and after the little exfoliations take place, the whole of both extremities become entirely covered with granulations, and ready to adhere to any healthy tissue they may come in contact with. This is what occurs in favorable cases. In the unfavorable cases, the soft parts become extensively implicated in unhealthy inflammation and suppuration which the bone, both externally and internally, may propagate to the articular extremities, and even involve one or more joints.

In the favorable cases, while the healthy action above described is going on in the ends of the bones, the periosteum is throwing out bony matter; and there is every reason to believe that the surrounding tissues play a decided and important part in this osseous deposit, for I have seen, in the humerus, particularly where the weight of the forearm drags down the lower fragment in fractures after considerable loss of bone, or rather perhaps holds the lower fragment about the position it held before the injury, the muscles not contracting with force enough to draw it up,—I say I have seen in such cases a gap of full two inches hedged over and around by cortical formation, inclosing an internal cavity filled with fragments. The proof of this bony formation filling up the interspace was given in the facts, that bone, periosteum, and all were removed for at least two inches, and yet perfect bony union took place *without any shortening*.

of the limb. The case of General Adams was one in point.

Where, in such cases, the granulating ends of the bones can be brought in contact, adhesion and subsequent firm bony union readily follow. Where, on the contrary, a gap is allowed to remain between the bones, while suppuration is progressing, more or less exfoliation often occurs—a cortical structure forms around them, leaving a cloaca to which a fistulous channel leads. Under such circumstances, the incasing bone forms very slowly, being greatly interfered with by the inflammation and suppuration kept up by loose fragments of bone. Three, four, six, twelve months may pass before there is consolidation enough to prevent motion at the point of fracture.

These, I repeat, are embarrassing cases; if the surgeon waits too long, such an amount of callus may be thrown around the necrosed bone, and the soft parts become so thickened and indurated, as to obscure everything and make operative interference exceedingly difficult. On the other hand, if he interferes too soon, the inflammation is aggravated, suppuration increased; there is risk of hemorrhage calculated to injure a debilitated subject, and the bone not being in condition for removal of all the dead parts, the case is set back materially, or much aggravated.

In the cases of *exposed* necrosing bone, in stumps, where the progress of the exfoliation can be watched from day to day, we never can be at a loss for the point of time at which the surgeon should interpose, but the condition of parts under consideration is very different. Here the work of nature is all hidden from view, and the difficulty is to know when nature has finished her

work and the time for the surgeon has come. There are no abstract principles on which we can rely; the detachment of the necrosed bone may require two, three, six, or more months, and if morbid action is *progressing* from point to point, years even may be consumed before it is accomplished; but such examples are rare. Most of the cases that have consulted me have been treated for several months in military hospitals, or by surgeons in the country, before coming to me.

Whether the time after the injury had been three months or three years, I have not hesitated to introduce a director into the fistulous opening, cut down to the bone, and make a full reconnoissance of its condition. If the necrosed bone is detached, remove it; if not, close the wound, except a small opening for a tent, and wait till nature has completed *her* work.

I am deterred from this course only by high local inflammation, or great constitutional disturbance, with prostration, etc.

Both reason and experience justify such procedure; no one can calculate the mischief which may arise from the retention of one or more fragments of dead bone; while on the other hand, a simple incision adds little to the local and nothing to the constitutional irritation. Give the patient chloroform, make a sufficiently free incision with a keen knife to allow the finger to be introduced; if there is loose bone, remove it; if there is not, close the wound, retaining a tent or bit of lint, and await patiently the process of nature. There are now thousands of poor fellows, mutilated by this war, who might have been saved months or even years of suffering, to say nothing of the loss of life, by timely operative interference.

ADDENDUM No. 1.

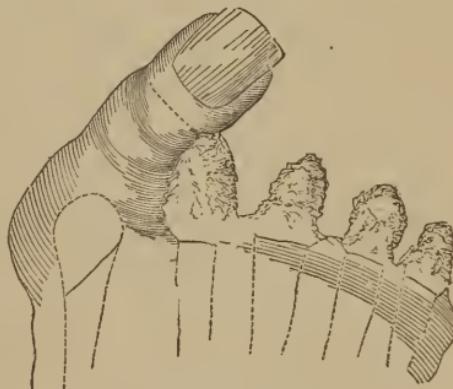
I HERETOFORE laid it down as a rule, that when a stump bone is exposed and projecting from deficiency of flap (from whatever cause) and is necrosing, it should, without interference, be intrusted to the process of nature for its amputation, and not be subjected to a secondary operation by which the inflamed soft parts would have to be cut loose with a knife, and the saw then applied an inch or two above the end, say one, two, or three weeks after the primary amputation. I have said that it was best to wait until the bone had sloughed off and entirely healed over, and if it formed a conical inconvenient projection, a secondary operation might then be resorted to, to rectify the difficulty.

I believe still that the above is the best *general* rule, but I have witnessed some cases which satisfy me that there are exceptions, in which much time may be saved by selecting proper cases and proper time for interference.

About six months ago, I was asked by Dr. F. A. Ross, of Mobile, to see in consultation with him Mr. Brenan, who a week before had had his foot severely wounded by a railroad accident. The four small toes were badly bruised, the sole of the anterior part of the foot lacerated, and the skin on the dorsum of the foot and back of the toes, for two inches, scraped off, and the big toe alone was left intact.

The four small toes I found completely mortified, and clipped them all off with scissors at their articulation with the metatarsal bones.

The parts suffered severely from inflammation and burrowing suppuration between the metatarsal bones and plantar fascia; but improvement went on gradually, the sinuses closed, the ends of the four bones were covered with healthy granulations, and the new skin advanced from the foot all around to the base of the projections formed by the metatarsal bones. The accompanying rough sketch from memory will give an idea of the appearance presented at the time of operation.



The dotted lines mark out the metatarsal bones.

The big toe is sound, but much drawn out of position by its flexors. The ends of the four metatarsal bones are seen rough with granulations, and projecting. A black line crosses each of the four small bones at right angles, showing the points at which they were removed by bone nippers. An oblique black line is also seen on the metatarsal bone of the great toe, indicating the point at which it was sawn off.

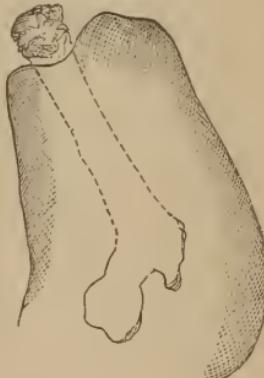
It would have been bad surgery, under any circumstances, to have left the great toe standing alone, as it would have been a great impediment in walking, and I therefore determined to make a complete stump at once. I amputated the great toe in the manner usually recommended, and at the same time with bone nippers removed the ends of the four

small bones on the same level. As expected, these bones had become so vascular and soft that they cut without resistance, like cork. The cut ends immediately threw out healthy granulations, and the whole stump soon healed over.

In another case, McKoy, a soldier, aged thirty-seven, in whom I amputated a thigh at the middle, for the relief of a terrible neuralgia, the result of a previous amputation. I removed, in like manner, the granulating extremity of the bone. The limb was removed by the rectangular flap operation of Mr. Teale; there was abundance of flap, and the stump seemed in every way satisfactory. But the patient having been suffering for nearly three years with neuralgia, his nervous system being much deranged, and the neuralgia not at all relieved by the operation, it was impossible to keep the stump quiet; it was constantly subjected to both voluntary and involuntary motion, and every time it was raised, the psoas and iliacus muscles drawing it inward as well as upward, the end of the femur protruded at the inner angle of the wound. As soon as the stump was replaced on its pillow, the bone receded to its proper position beneath the flap.

The accompanying sketch, from memory, will give a sufficiently accurate idea of the manner in which the granulating extremity of the bone protruded when the end of the stump was elevated.

The first consequence of the constant motion, friction, and exposure of the bone to air, was partial necrosis; a thin scale half an inch wide, a line in thickness, and covering the anterior half of the sawn extremity, exfoliated, and was thrown off at the end of twenty-seven days after the amputation. The whole stump had healed except the open-



ing through which the bone played at the inner angle; and the bone, which projected an inch or a little more when protruded, as well as the cavity in which it lay when retracted, had become covered by an adventitious membrane similar to that of old sinuses. The end of the bone, when protruded, was not unaptly compared by a by-stander to the glans penis of a large dog, being perfectly red and smooth like the object of comparison.

After trying in vain by means of caustics, retentive bandages, and adhesive straps, to keep the bone in place and heal the parts over it, I determined to excise it, being satisfied that it was sufficiently soft from its increased vascularity to be easily removed with bone nippers, which was done.

Although the femur would have defied any instrument of this kind in its normal state, it was in this condition nipped off with perfect ease. I then had no difficulty in closing the soft parts over the orifice left, by adhesive straps and bandage, and the wound soon closed without any unpleasant symptom. The bone in this condition of increased vitality, which is equal to that of a muscle, granulates and heals readily.

Nature in this case had done all the amputating she was capable of, the necrosed portion had been thrown off, and the remaining bone forced into an abnormal degree of vitality. After the exfoliation, the end of the bone was left covered by granulations, which soon became coated with an adventitious membrane, that could not unite to the surrounding parts, particularly when disturbed by constant motion.

Now the practical points in this case and the one of Brenan, as well as the pathological conditions, are the same. Nature had in each case thrown off by exfoliation the condemned portions of bone—had left the ends vascular and softened—the remaining part of her work would not only have been accomplished with difficulty, but would have ended in very unsatisfactory results; cicatrices would have formed over

these projecting bones after the consumption of much time, but the cicatrices would have been projecting, conical, sensitive, subject to abrasion, and altogether sources of discomfort and annoyance. In the case of the foot, it was clear that the patient could never walk, with or without a shoe, until a new stump was made by an operation.

When the end of a bone is necrosing, the sound bone above the line of demarkation always becomes more vascular and softened (as in the two examples just given), and after a certain time may be easily divided by nippers, or even strong scissors. A question has therefore arisen in my mind, whether the practical bearings of this fact have not been too much overlooked.

Where the process of exfoliation is slow, or where after the exfoliation is accomplished, it is clear that there will be an undue projection of the bony point of the stump, may we not only gain time but a better stump, by removing the projecting bone at an early period by properly shaped bone nippers, which may be glided up the bone beneath the overhanging granulations and made to divide it transversely? It is impossible in such cases to remove the bone with a saw without disturbing the soft parts around more than would be prudent, and moreover, *cutting* would do much less violence to the softened bone than the rude action of a saw.

The important practical point in such cases would be the *question of time*. At what period after amputation would it be prudent to remove the extremity of the bone as above proposed? This would necessarily vary much according to the circumstances of the case. Sometimes a stump will do well for a week or two after amputation, and then be seized with gangrene and the bone become exposed; at other times, from immediate gangrene, or from deficiency of flap, the end of the bone is exposed at the offstart, and the work of necrosis commences forthwith. In other cases, as that of Brenan,

the bones are exposed by the direct action of some mechanical injury.

The following general rules will apply to almost all cases: When the end of a bone is exposed, wait until the process of exfoliation is fairly under way, the surrounding inflammation subsides, and *healthy reparation* is going on in the whole wound, then with an awl, exploring trocar, or the point of a narrow bistoury, puncture the bone and determine whether it is soft enough to be easily divided by bone nippers or strong curved scissors. In the small bones twelve to fifteen days, and in the larger from fifteen to twenty-five, would be sufficient to justify the operation.

If the wound be gangrenous or pale, ulcerative and discharging unhealthy matter, any such procedure would be likely to result in more harm than good, and should not be undertaken.

I confess that my experience in such cases has not been sufficiently long and varied to justify me in laying down any positive rules, but I am satisfied there is here a field that has not been sufficiently explored, and all I hope is to attract the attention of others to it.

ADDENDUM No. 2.

I HAVE, during the war, witnessed a number of cases of neuralgia following gunshot wounds and amputations, which I may work up at some future day, and can make room at present for but two cases, which are of unusual interest, both from their novelty and practical bearings.

Case 1.—This case is the same one of Marshall McKoy, a soldier, aged thirty-seven, already alluded to in *Addendum No. 1*, in connection with the treatment of a stump after amputation of the thigh, and will for the present complete the history of this extraordinary example of human suffering and complicated surgery.

The subject had his leg crushed above the ankle by a railroad accident, 1st August, 1862, and was amputated on the twelfth, about the junction of the lower with the middle third, by a regimental surgeon. According to his statement, the operation was not well done, the bone being left exposed from insufficiency of flap. The amputation was performed at the Greenville hospital, Alabama. Two months after the amputation he obtained a furlough, though the stump was not healed, and went to his home in Mississippi. The weather at the time of his journey was very cold, and he thinks he "took cold in the stump," as neuralgia, the source of his subsequent troubles, commenced soon after.

Some time during the early part of the summer of 1863, he came to Mobile to consult me, and I then saw him for

the first time. He was, and had been ever since the time above alluded to, suffering intensely with neuralgia in the stump. I advised a second amputation, to which he objected, and returned home. After continuing to suffer at home, he was again amputated by Dr. J. M. Baylis, on the 11th September of the same year, 1863.

He continued to suffer without intermission, and came back to consult me about 1st May, 1864, and finding no relief from any remedy I could recommend, and thinking that some twig of nerve might have been inclosed in a ligature at the last operation, I advised a third amputation, to which he submitted on the 19th of May, 1864.

I made a double skin flap, took off only about one inch of the stump, and sawed off the bone just below the tuberosity of the tibia. The stump healed by first intention; the ligatures all came away in ten days, and in a few more the parts were entirely healed over. On examining the part removed, the portions of two large nerves removed were found enlarged and engorged.

No relief whatever followed this operation; the pain was not referred to any particular spot or spots, but was diffused over the whole surface of the stump, and so intense as to make existence intolerable. Opiates, which he bore badly, stupefied him and deadened sensibility for a time, but narcotics, arsenic, quinine, iron, etc. never afforded him any relief.

On the first of June following, the pain being still referred to the stump, I cut down at the upper part of the popliteal space, exposed the ischiatic nerve, and took out about an inch of the trunk and a portion of the popliteal and peroneal nerves, altogether about three inches in length. The nerves were all enlarged, and, no relief following, he returned home in despair.

On 1st May, 1865, he returned to Mobile to see me, nearly twelve months after the last operation, still suffering,

and having had no intermission except for a few hours at a time.

The pain was still, as it had been invariably, in the end of the stump, and although there was perhaps no very good physiological reason for so doing, I cut down upon the popliteal space and dissected out the two large nerve trunks completely down to the extremity of the stump. Still no relief.

I may here remark, by way of parenthesis, that the reader will find some excuse in Case 2, following this, in which the function of the median nerve was perfectly preserved after the excision of five inches of its trunk.

As may be well imagined, I was at a loss what to suggest next, having lost all faith in surgical operations. Still the man called loudly for relief, and said he could not endure his suffering. I next proposed, discouraging as the prospect was, amputation of the thigh, to which he consented.

The amputation was done about four inches above the knee, on 27th May, 1865, by Teale's rectangular flap method. The flap behind being short, gave me an opportunity of dissecting up the ischiatic nerve about three inches above the sawn extremity of the bone. The nerve even up to that point was engorged and double its normal size.

The stump was a little tedious in healing, from causes detailed in Addendum No. 1, but finally did well and made a good cure so far as the amputation was concerned, but without any relief to the neuralgia.

He still called for relief at any hazard, and I proposed, as a dernier ressort, excision of the ischiatic nerve, at its point of exit from the pelvis. To this he consented, and on the 28th August, 1865, I cut down behind the trochanter upon the nerve midway between it and the tuber ischii, and removed a little more than an inch of the nerve immediately below the pyriformis muscle. The nerve here is deeply seated but easily got at, the skin, areolar tissue, and gluteus

magnus being the only parts to be cut through. There was no vessel of any size divided, but there was continuous bleeding from small branches at the bottom of the wound, which being difficult to get at, it was stuffed with a wad of cotton dipped in persulphas ferri, which arrested the flow instantly. The cotton was removed a few hours after, but healing by first intention was prevented by the styptic. The wound soon granulated and healed rapidly.

For the first time in my various operations, I in this last one reached a part of the main trunk of the nerve which appeared to be sound. The piece removed in this operation was an inch and a quarter long, and when examined, the upper half looked perfectly healthy in size, color, and texture, while the lower half had a diseased appearance; it was enlarged and engorged with blood. I was much encouraged too by the fact that on my visit the next day, he expressed himself as greatly relieved for the first time, and confident of cure.

The following day, however, I found he had passed a horrible night and was suffering as much as ever, and still referring the pain, as he had done after every operation, to the *extremity of the existing stump*. Even in the two instances in which I resected the nerve, the pain was referred to the stump, as it had been in every amputation.

The last operation was on the twenty-eighth of August, and although after healing of the wound he left Mobile for his home about the first of October, a month afterward, asserting that he had experienced no relief from the last operation, I am satisfied that he was much benefited by it; his general health, appetite, digestion, etc. were much improved, and he no longer gave evidence to the nurses and others of the severe neuralgic pains which had previously tormented him. He had suffered so long and so severely that he had become an opium eater—taking as much as twenty grains of morphia daily. In order to procure the

opiate, he would often make bitter complaints, when I was satisfied he was suffering but little.

This case is certainly one of the most remarkable on record in several points of view. The limb was first crushed by a railroad car, he was afterward subjected to three amputations of the leg, one of the thigh, and three resections of the nerve. It is interesting too in a pathological and physiological point of view. It is unusual to see inflammation follow up the trunk of a nerve as it did in this case, and it is difficult to say why the pain should invariably be referred to the extremity of four stumps in succession. The above history extends over a period of three years.

Case 2.—The subject of this case, Mr. Wysinger, aged about fifty, of robust constitution, lives at the little village of Citronelle, thirty miles above Mobile.

He came to consult me about twelve months ago for a tumor, which had been growing fifteen years on the front of his forearm; it had never interfered with the functions of the hand or arm, and had never given the slightest pain or inconvenience until two or three months before consulting me, when it commenced giving him a good deal of pain in the fingers, and produced partial contraction of the little and ring fingers.

The tumor was about the size of a cocoanut, oblong or egg-shaped, and extended from an inch below the bend of the arm to within an inch of the wrist; it was elastic, and presented the characteristics of an encysted tumor.

He readily consented to its extirpation, and in the presence of Dr. Henderson, Dr. McCleskey, and several younger members of the profession, I made an incision its whole length along a line drawn from the tendon of the biceps muscle to the center of the wrist. On dissecting down carefully, I discovered, to my surprise, that it was a neuromatous encysted tumor. At its upper part the trunk of the median nerve was seen to enter it, and immediately to expand its

fibers widely over the whole anterior surface of the sac; at the lower border of the tumor they were again collected into a common trunk. The expanded fibers were so completely incorporated with the sac that it was impossible to liberate them from it by dissection. I therefore divided the nerve above and below the tumor and dissected out the entire mass. The adhesions were slight and there was no difficulty in turning out the sac, which had been punctured and partially evacuated. It is remarkable that the contents of the sac presented the appearance simply of grumous blood, though of fifteen years' standing. Vidal de Cassis, in his *Pathologie Externe*, reports a case very similar in every respect, the only one I know on record.

Though interesting pathologically, I have reported this case mainly on account of its physiological bearing.

Although at least five inches of the median nerve were removed, its functions were not interfered with in the slightest degree. The operation was followed by neither paralysis nor loss of motion, and the neuralgic pains, which had occurred two or three months previously to the operation, disappeared entirely. I have been in the habit of meeting this gentleman frequently during the twelve months which have followed the operation, and he assures me all the functions of the fingers are perfect.

The tumor had been growing slowly for fifteen years, and as the function of the median nerve was probably gradually destroyed, nature made provision to supply its place; but how it was done, I must leave to wiser heads than mine to explain.

